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INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

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Devoted to Measurement and Control Problems

Vol. 3. No. 4 Pittsburgh, Pa. April, 1930

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New Instruments

- A New Motor Starting Ammeter
- A Shock Absorber for Pressure Gages
- Thread Profile Gage
- Optical Indexing Device
- New Position Recorder
- Improved A C—M E Specific Gravity Balance
- Optical Drill Gage
- Hot Molding Pyrometer
- New Overload Switch for Small Motors
- Pattern No. 41 Ohmmeter
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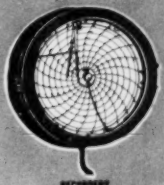

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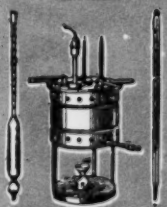

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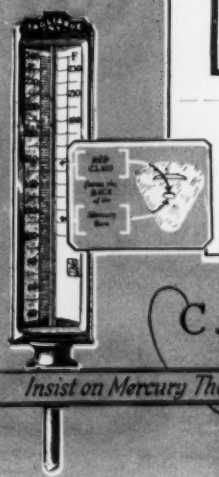

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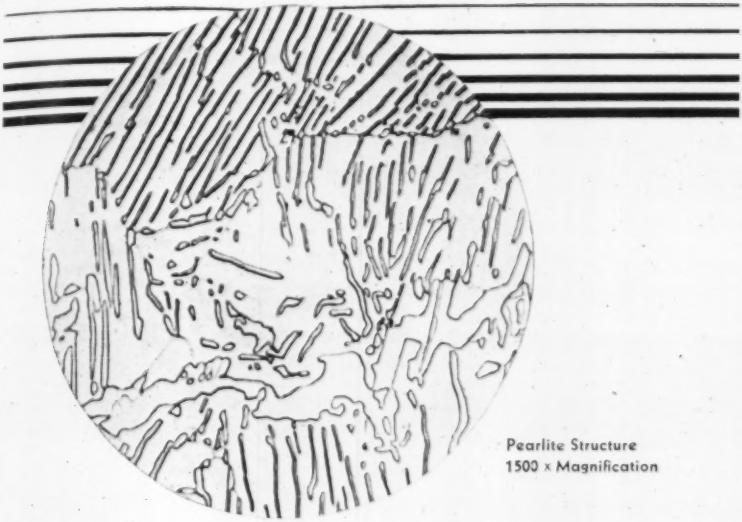

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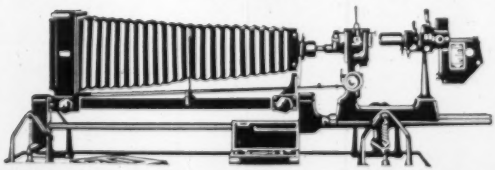

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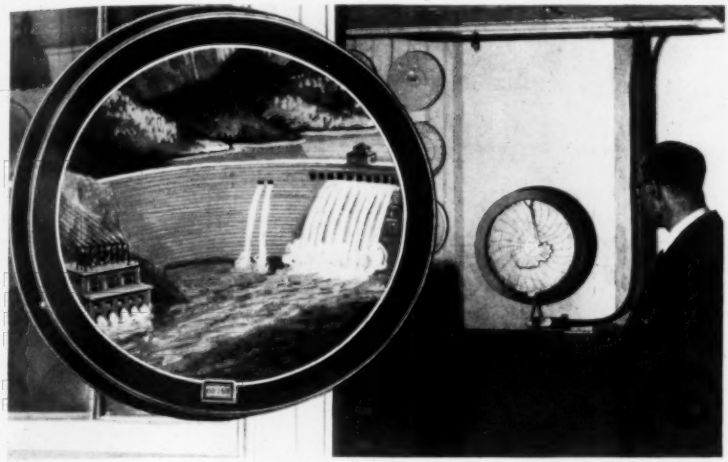

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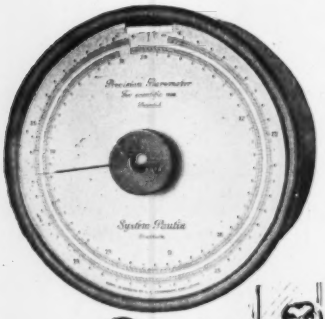

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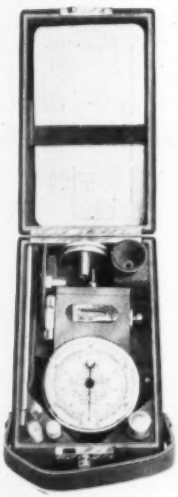

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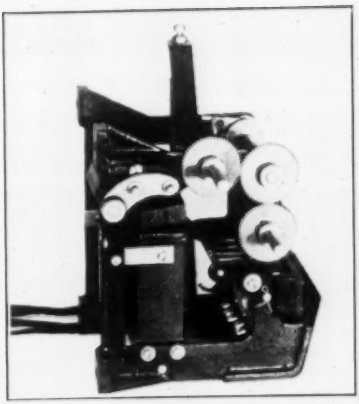

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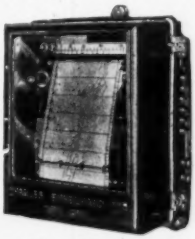

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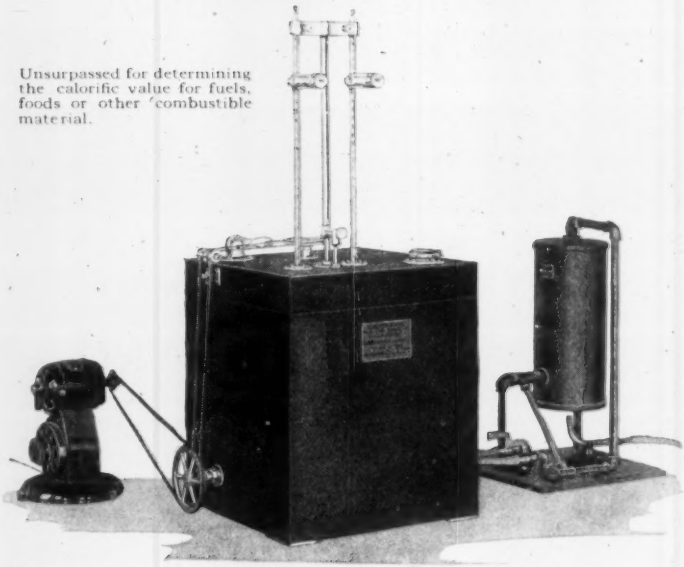

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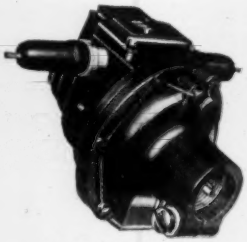

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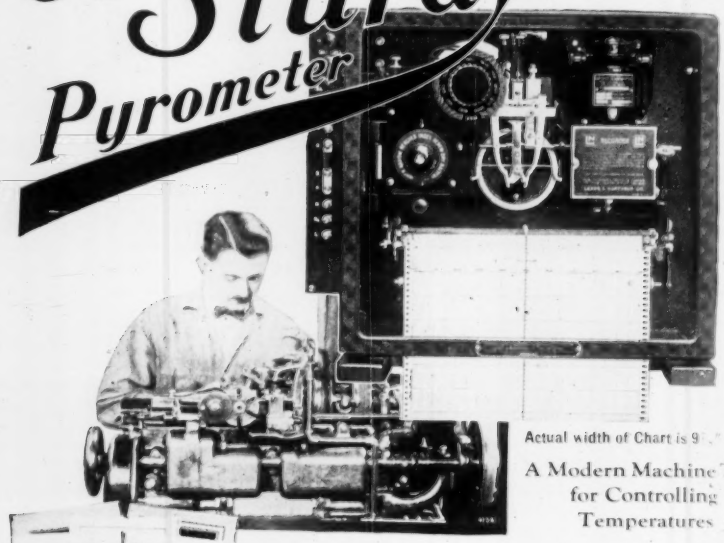

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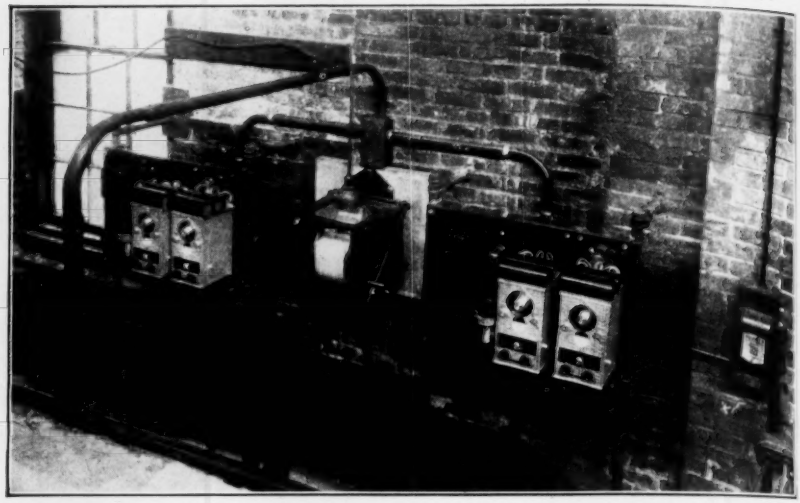

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Vol. 3, No. 4 APRIL, 1930 Pittsburgh, Pa.

To Our Readers

IN the various stories of trick flights we find considerable space devoted to the instruments—the instruments mounted in the plane. There is no doubt that these instruments contribute very materially to the success of the flights—but the meterological instruments used by the airport and weather observatory are just as important.

In spite of the advances made in aircraft construction the success of a long distance flight is still, in a large measure, dependent upon weather conditions

A very interesting paper entitled "New Aircraft Instruments" was read by Captain S. J. Zand, Aeronautical Engineer, Taylor Instrument Companies at the Pittsburgh Aeronautic Meeting of the American Society of Mechanical Engineers on March 12th. In his introduction the author briefly traced the increasing application of instruments in aviation, explaining the essential characteristics of such instruments.

In the discussion of the paper, Captain Zand brought out that very often there was not sufficient forethought used in planing airports. Usually in the case of the construction of an airport, thousands of dollars are spent for purchasing the ground, leveling it off, constructing the hangar, etc. and when everything is ready, it is found that no money is left for ground instruments.

This condition is not peculiar to airports, but is met with in the construction of many manufacturing plants and even laboratories. A recent case which has come to the attention of the editor is a research laboratory, which constructed a building costing close to a million dollars. This laboratory lacks a number of instruments necessary to carry on some of its problems, but makeshift means are used as the money required for the purchase of the instruments is not available.

A subterfuge used by the editor, when he installed a research laboratory several years ago, was to purchase the instruments on the installment plan. Most companies have a rule that all purchases amounting to more than one hundred dollars, must be passed by the general manager or some body else. If the instrument cost about three hundred dollars, three repair orders, each for one-third the amount were issued.

Another Reader Recognizes the Advantages of Instruments' Make-up.

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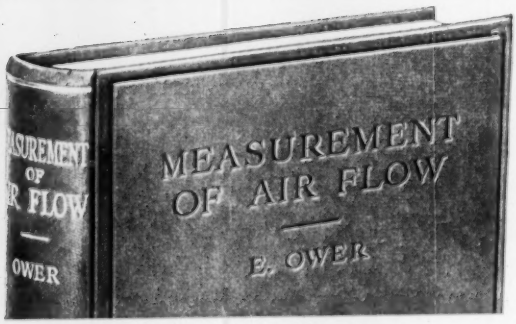
By

E. OWER, B.Sc. (LOND.), HONS. I., A.C.G.I.

Bramwell Medallist; Member of the Institute of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory.



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CHAPTER II

Industrial Temperature Instruments

(Continued)

Part 3—INDICATING PYROMETERS

1. General Remarks

As in the case of Part II, which discussed only indicating thermometers, this part of the temperature instrument chapter will discuss only indicating pyrometers, leaving for subsequent parts the descriptions of the mechanisms and circuits peculiar to the recording and to the controlling instruments.

In Table I, the classification of indicating pyrometers divided them into (1) thermo-electrical, (2) optical, (3) radiation and (4) fusion. The first three classes, in their industrial forms, are made up with scales across which pointers travel. The fourth class, comprising pyrometric cones, was designated as "supplementary." In the following discussions, therefore, the first three classes (and the types within these classes) can conveniently be compared with one another, but for obvious reasons the fusion cones must be considered as a separate class, not subject to comparisons, for they are not *temperature measuring* devices and we included them in Table I for practical, not logical reasons.

Greater progress has been made in industrial pyrometry since the world war than in the century preceding it. Pyrometry seems to be one field in which the laboratory is indebted to the plant. Had it not been for the many remarkable developments and exquisite refinements in industrial pyrometers in recent years, it is possible that the International Conference on Weights and Measures (including our own Bureau of Standards) might not have honored the thermocouple and the optical method by assigning to each of them a place as a primary international standard of the International Temperature Scale.

Recent developments, indeed, make it necessary to point out also that many of the tables of fixed points in fairly recent textbooks and reference works are obsolete—the exact values in degrees International having lately been determined beyond doubt, so that discrepancies among the books other than International tables need no longer perturb metallurgists and other engineers.

A comparison of the three classes of pyrometers along scientific lines is of little interest here; but from a practical point of view, a comparison is both obvious and simple:

1. The sensitive element of thermoelectric pyrometers is generally immersed and is almost always a contact element, whereas both radiation and optical pyrometers are sighted from a distance.

*Engineering Editor

2. Therefore, there is an element subject to wear in thermoelectric pyrometers which is not found in the other two classes.

3. With thermoelectric and radiation pyrometers you can get temperature indications on panel-board instruments and get temperature records on charts, and you can readily install multiple-switching arrangements. With an optical pyrometer you can only measure the temperature of one thing at a time—the object you sight—and you cannot obtain temperature records—at least not in this year 1930. (We are speaking, of course, of industrial instruments on the market. It is scientifically easy to replace the human eye by an electric eye and connect up a vacuum tube amplifier and a recording meter to the photometer . . . It *will* be done for industrial applications before long!)

4. The conditions for high accuracy in the use of thermoelectric and optical pyrometers are fairly easy to realize; on the other hand, such commonly overlooked factors as invisible gases and vapors may seriously affect the readings of radiation pyrometers. Therefore, the latter are considered "less accurate"—for *use*, not intrinsically— than the other two types. Under standardized industrial process conditions, however, their indications can be just as dependable even though they may not be indications of the true temperatures.

5. As regards simplicity versus complexity, class distinctions have now ceased to exist—among these three classes. Certain types and models in any one class are much simpler, and others much more complicated, than types and models in other classes. The same applies to ruggedness: in each class there are both robust and delicate instruments.

6. As regards the amount of skill required, we must first ask the question, what sort of skill? Certain it is that optical pyrometers require some "skill of observation" which the other classes do not. Then too, "skill of sighting" is very necessary with portable radiation pyrometers, somewhat necessary with optical pyrometers and quite unnecessary with thermoelectric pyrometers. It is possible, however, to sight radiation pyrometers once for all by attaching them securely in one position at a definite distance from a peep-hole or a refractory tube. A certain amount of skill is required regardless of class in following the manufacturer's general directions when a permanent installation is made. The "maintenance skill" required does not depend so much upon the class as upon the particular construction and circuit of the instrument and of its auxiliaries if any. Above all, skill—or, rather, experience and judgment are almost always required to detect and promptly remove causes of inaccuracy. See below under "Troubles."

7. Causes of inaccuracy may arise within the elements of the instruments or systems. Some of these will be dealt with below. But the most important causes of faulty indications arise outside of the instrument—in the installation. Some of these have been referred to in a general way in Chapter I and also in Part I of this chapter. It is well to emphasize the fact that eternal vigilance is the price of continuously accurate measurements of high temperatures on industrial applications. Pyrometers of all classes have been improved, refined, simplified, and made easier to use, but the foolproof pyrometer has not been invented and perhaps never will be. Nor will anything ever take the place of sound technical training as a requirement for getting the most out of any class or type of pyrometer.

2. Thermoelectric Pyrometers

Principle. No scientific law is involved. The "thermocouple effect" is simply the generation of an electric current in a circuit that includes dissimilar metals in contact—the electro-motive force increasing as the temperature differential increases—such increase being known in advance with as much accuracy as the coefficients of expansion of mercury and of various gases . . . provided the thermo-elements are pure.

The "thermocouple effect" is the sum of two other effects—theoretically the algebraic sum but fortunately in practice the plain addition, which makes it convenient all around. An easy way of picturing just what happens is to remember that "*Seebeck equals Peltier plus Thomson.*" We deliberately omit a diagram here and ask the reader to get a mental picture from the following paragraphs:

Seebeck. Take two wires of dissimilar metals. Weld their ends (or just twist the two pairs of ends). You naturally get two "junctions." Heat one junction. The moment there is a temperature difference, a current flows in this circuit. This is what Seebeck discovered in 1821, but he let it go at that without knowing that there are two distinct causes of emf:

Peltier. Take two different metals. Place them in contact. The moment there is contact, an emf is set up. This emf varies according to the metals and to the temperature—the one temperature of the one junction. Peltier discovered something like this in 1834 and the emf so produced is called the Peltier emf.

Thomson. Take a wire—a homogeneous metal wire. Heat one end of it. The moment there is a difference of temperature between the two ends, an emf is developed. The same happens when there is a temperature gradient between any two points on a wire. This is what William Thomson (Lord Kelvin) discovered. Thus we have the Thomson emf.

Essential Parts

The exact measurement of the Peltier emf and of the Thomson emf concerns only scientists and manufacturers of pyrometers. All the engineer need known in this connection is that in order to utilize the "thermocouple effect" it is necessary that the pyrometer outfit include the following:

(a) The hot end, inserted where the temperature is to be measured and embodying the hot junction, which is generally at the tip. The hot junction itself is the sensitive element.

(b) The cold junction, which usually is not one but two connections—between each of the thermocouple wires (or their extension leads) and the ordinary copper leads of the instrument circuit (or the brass terminals of the electrical instrument.)

(c) Some provision for keeping the cold junction at a constant temperature, or (and this is important in industrial plants) some provision for the automatic compensation for variations in cold junction temperature.

(d) An electrical instrument for accurately measuring the comparatively feeble emf. We have seen that this emf has two components (that is to say four or more as read by the instrument—depending on the circuit) but from now on we can almost forget this complexity, because industrial thermoelectric pyrometers are so designed and constructed—and are so installed when directions are followed—that all significant emfs are additive at all temperatures within the range of the instrument.*

*Strictly speaking there is an unavoidable Peltier effect in the wrong direction at the cold junction. But it doesn't matter in practice, the Seebeck effect or thermocouple emf increasing with the temperature differential if the couple materials are properly chosen.

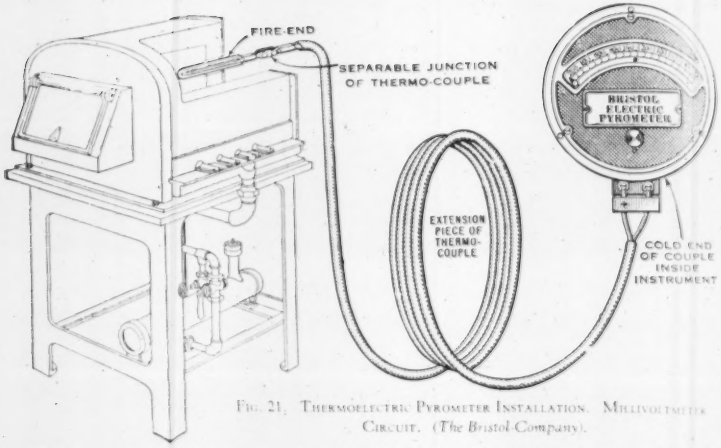


FIG. 21. THERMOELECTRIC PYROMETER INSTALLATION. MILLIVOLTMETER CIRCUIT. (*The Bristol Company*).

(e) Various appurtenances and features—some of them essential such as insulation, protection, etc., and some optional, such as styles of tubes, terminal heads, forms of circuits, construction of electrical instruments, etc.

The appearance of typical thermoelectric pyrometer outfits is excellently shown in Figs. 21 and 22. The first illustrates a millivoltmeter system, the second a potentiometer system. The difference is in the circuits rather than in the outward appearance. If the reader is just beginning to learn pyrometry he is strongly urged to study these two pictures.

Circuits and Methods.

When you want to know people, you study their minds rather than their photographs. The various parts of a thermoelectric pyrometer outfit which you buy, install and work with, are the "body;" the "soul" is the *thermoelectric circuit*, which must be understood to some extent in order to make intelligent use of thermoelectric pyrometers—especially after months of severe service.

In the last forty years, and especially since the war, a great deal has been

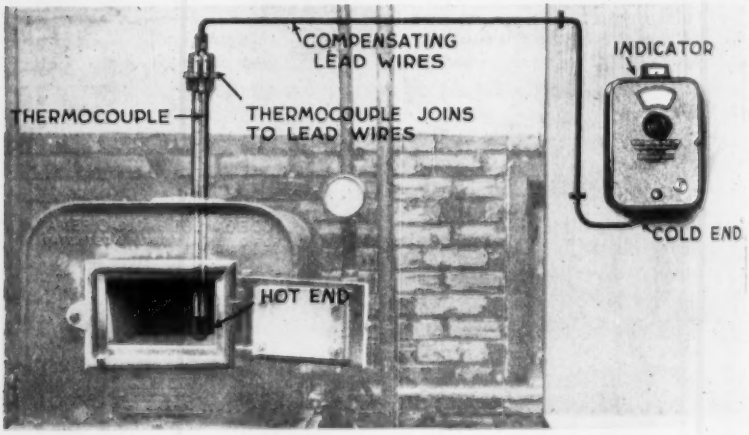


FIG. 22. THERMOELECTRIC PYROMETER INSTALLATION. POTENTIOMETER CIRCUIT. (*Leeds & Northrup Company*).

printed about the thermoelectric circuit. About fifty references are in the room where this is being written. Most of the scientific discussions are too long and deep for practical men; all of the "popular" treatments (so far seen) are more or less erroneous. Dozens of engineers in the Pittsburgh district could offhand present a more lucid explanation than 48 out of the 50. The following discussion is designed for plant engineers interested in pyrometers rather than in electrical science.

As good a way as any is to start off with the simplest possible circuit and go through the main points of the millivoltmeter circuit, taking up some questions applicable also to the potentiometer circuit, so that when the latter is reached, only its distinctive features may be dwelt upon.

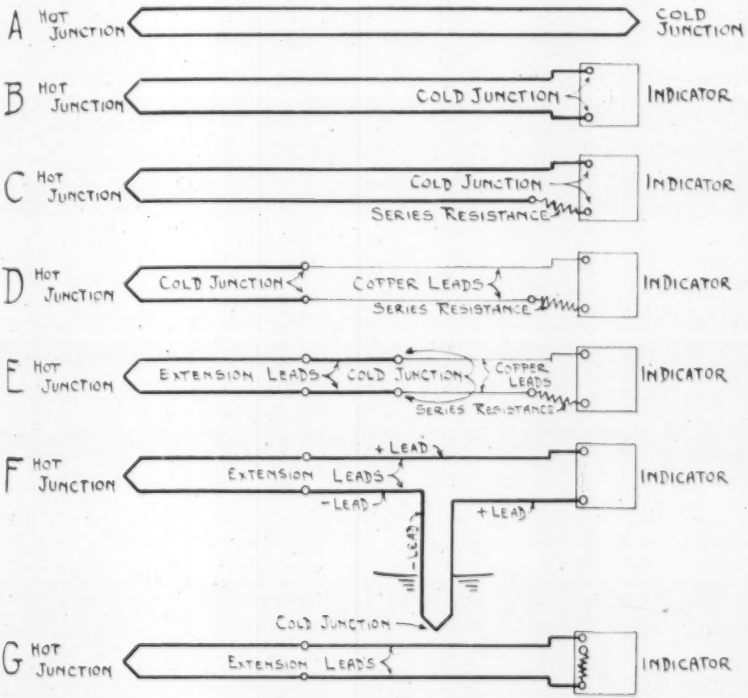


Fig. 23. Evolution of the Millivoltmeter Circuit

The Millivoltmeter Circuit. The simplest form of the thermoelectric pyrometer is shown at A, Fig. 23. If both junctions are at the same temperature there will be no Thomson emf, while the two Peltier emf's neutralize each other, being equal and opposite. No Seebeck effect—no flow of current. Now heat the hot junction. A current will flow, but we have no means of measuring it—we can't even know that it flows.

The next step, then, is to untwist the wires at the cold end and connect them to a millivoltmeter, as shown at B. Now we can measure the potential drop across the instrument terminals. These terminals, by the way, are commonly brass binding posts. New effects are created but they are mutually compensating if both connections are at the same temperature. It amounts to this: "metal X to brass; brass to metal Y," so that the *pair* of cold end connections remains in effect the cold junction. The emf in-

dicated by the millivoltmeter is *proportional* to the thermocouple emf — less than the true value, of course, on account of circuit resistance, but at any rate we can calibrate the scale in degrees of temperature.

It is not possible, however, to realize such ideal simplicity. In practice we can't put an instrument right at the terminal head of a thermocouple mounting. We must have an actual circuit (even in portable pyrometers as shown in figures 41, 43, 45 and 46). An actual circuit—not an ideal one—means a circuit in which the resistance of some portions will vary uncontrollably (poor contacts, corroded wires, "resistance thermometer effect," etc.) The answer is to introduce a fixed or controllable resistance so much higher than the rest of the circuit—where variations occur—that these variations will become negligible. Circuit C shows the idea—a "ballast" or *series* resistance. It usually is made of manganin, which has a zero temperature coefficient. There are other methods, discussed below.

In practice we want to save money by running copper leads from the furnace to a remote instrument. This modification is shown at D. But now we have seriously affected our circuit. Here is why:

A long copper wire acts as a resistance thermometer. Therefore we must make the series resistance still higher. Secondly, we must do something about the cold junction temperature, because the only current we are interested in (the one which deflects the millivoltmeter coil) is produced by the *difference* between the temperature of the hot junction and that of the cold junction.* If the cold junction is at the terminal head of the thermocouple tube, the heat radiated by the furnace in which the thermocouple is installed may bring up the temperature of the cold junction from room temperature to several hundred degrees, introducing serious errors. One way to solve this difficulty is to embody a compensating shunt in the terminal head, but this cuts down the current to the instrument and generally precludes using a millivoltmeter.

Another way is simply to lengthen the thermocouple so that its cold end will be moved away from the furnace. This need not involve employing *longer* pairs of perfectly homogeneous *thermocouple* wires, which would be expensive in the case of rare metal couples. The same effect is achieved by connecting to the terminal head special homogeneous flexible conductors serving to *extend* the couple so that the cold junction may be properly handled. For base-metal couples these pairs of conductors may be made of the same two metals or alloys as the couples, but in the form of insulated stranded cables for convenience. The obvious designation for such cables or leads is *extension leads.*** Fig. 23E shows the circuit thus obtained. The cold junction now consists of the two connections of the extension leads to the copper leads, and it may be located where its temperature can readily be kept constant and *known*.

When extension leads are of materials *different* from those of the thermocouple, additional Peltier emf's are set up. This is inevitable. Likewise, additional Thomson emf's are set up, for we have in effect another pair of thermocouples. Our circuit is apparently getting complicated, but as a matter of fact the pyrometer makers have taken advantage of these phenomena, with the result that in the case of rare-metal couples extension leads

*Hence the advocacy, by some pyrometer experts, of calling the hot junction the *measuring* junction and the cold junction the *reference* junction. The author votes yes, but this Handbook cannot undertake—beyond this footnote—to aid the movement for making practical men change their cherished terminology "overnight."

**In this case the author does not hesitate to take issue with the authors of all reference treatises on pyrometry who call such leads *compensating* leads.

can be made of inexpensive alloys, the temperature-emf relations of which are such as to nullify undesired effects on the indications of the instrument. Such leads are known as *compensating* leads. Their main purpose is to counteract the cold junction emf at the terminal head and set up an emf at a point away from the furnace, "removing the cold junction" as do extension leads made of the same materials as the couple. Compensating leads are being used in various ingenious ways in the circuits of millivoltmeter pyrometers on the market. There is no space to discuss the many interesting possibilities, but Fig. 23F shows how for example the cold junction may be made to consist (physically) of *one* junction. This is of great advantage in multi-switch installations—one indicator connected to a number of thermocouples. The electrical problems of such circuits have been worked out by the manufacturer, and as far as the user is concerned the circuit is as simple as it looks in the figure.

The same may be said of circuit G. The indicating instrument contains not only the series resistance but the cold junction and also a mechanical or electrical arrangement which obviates entirely the need of keeping the cold junction at a constant temperature (see below under "Cold Junction Compensation") Instead of having the cold junction half way between the furnace and the indicator it is removed all the way up to—and inside—the instrument case. The circuit is simplicity itself . . . as far as the *user* is concerned. We can let it go at that!

The Question of Resistance—This pyrometric question reminds one of prohibition; arguments between "highs" and "lows" broke out at about the same time as those between wets and drys—and still rage. The main facts:

1. A thermocouple develops a very feeble emf (See Chart 1). Hence the need of a sensitive instrument.

2. Pointer deflection depends on torque. Torque depends on ampere-turns in the moving coil. It is a matter of *current* because you can't increase voltage.

3. The lower the resistance, the higher the amperage—the more current available for the moving coil. But——

4. With a very low resistance instrument, variations in line resistance produce incorrect temperature indications (as explained on the opposite page).

5. Introducing a manganin series resistance of several hundred ohms "eats up millivolts," reducing the emf available for conversion into ampere-turns.

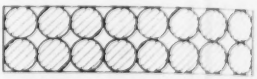
Actual figures are now given for typical circuits:

	Rare-metal	Base-metal
Resistance of thermocouple when cold	2 ohms.	0.1 ohm.
Probable variation of thermocouple resistance due to sertion to different depths and into furnaces at different temperatures	1 ohm.	0.01 ohm.
Resistance of copper leads	1 ohm.	0.25 ohm.
Resistance of copper coil in millivoltmeter	24 ohms.	2 ohms.
Probable change in resistance of leads and coil due to change in atmospheric temperature	1 ohm.	0.09 ohm.
Probable consequent total change in circuit resistance	2 ohms.	0.1 ohm.
Minimum total resistance by addition of a manganin series resistance in order that above change in resistance does not exceed 1% of the total resistance	200 ohms.	10 ohms.
Emf of thermocouples at 1800°F	10 millivolts	40 millivolts
Current flowing in moving coil generating the torque (milliamperes)	$\frac{10}{200} = 0.05$ m.a.	$\frac{40}{10} = 4$ m.a.

It will be seen that the "amperage" of the base-metal couple circuit is eighty times that with the rare-metal couple. In practice the actual torque can only be thirty to forty times as large. Here we must consider the practical problem of making use of the amperage while obeying Ohm's Law.

Say we have a current of exactly one ampere passing around a coil four times, through a thick wire whose resistance is one ohm. We can get the same torque in another coil, with only one-quarter of an ampere, if we use sixteen turns. But can we get one-quarter of an ampere? If we cut down the diameter of the wire one-half, we can get the sixteen turns, which will have the same cross-sectional area and the same weight. But the resistance of *each* turn will be *four* times as high, and the *total* resistance of the coil will be *sixteen* times as high. Therefore, with the same emf of one volt, we will have only one-sixteenth of an ampere passing through it, and we can only obtain one-fourth of the torque.

Thick wire, few turns. Low Resistance



Thin wire, many turns. High Resistance

This electrical dilemma is complicated by difficult problems of practical instrument-making in the case of high-resistance instruments in which the available torque is very small. Friction then becomes so large a factor to be conquered that in general we find that the high-resistance instruments on the market are of the vertical coil type (Figs. 38, 39 and 42), and only those instruments known as medium-resistance indicators have horizontal coils (Figs. 21, 40, 41, 43 and 45).

Now let us go back to the above typical figures. The resistance of the copper leads in the base-metal circuit was given as only one-fourth of that in the rare-metal circuit—which is usual practice. It will also be noted that the variation in resistance of the typical rare-metal couple is much greater than that of the base-metal couple. This is because rare-metal thermocouple wires are of very small cross-section—and the reason for that is that platinum is expensive. Moreover, even if you paid $1000.00 for a special low-resistance rare-metal couple constructed like the iron-constantan couple illustrated in Fig. 35, the emf developed would remain the same.

In view of these considerations it is possible to lay down two broad statements:

(1) *With a rare metal couple it is always better to use a high-resistance instrument.*

(2) *With a base-metal couple and short leads to the instrument it usually is preferable to use a low-resistance instrument*—what the manufacturers call a medium-resistance instrument. This is also advisable mechanically, because an indicator placed close to a furnace or other apparatus may be subjected to vibration and occasional shocks and must therefore be *rugged*. Ruggedness is realized with low-resistance (high-torque) indicators more easily than with high-resistance instruments—other things being equal.

This does not mean that high-resistance *industrial* instruments are delicate. Witness the following quotation: "As proof of what instruments so constructed will stand in the way of rough handling, we ship them without clamping the moving system. The handling they receive in use is gentle compared with what they receive during shipment."

Inasmuch as the ideal proportions of the various resistances in a pyrometer circuit are unattainable, each manufacturer has worked out the optimum proportions for circuits consisting of standardized thermocouples, extension leads, and indicators. As a rule, it is unwise to depart from the specifications recommended by a manufacturer for any industrial application.

Line Resistance Compensation—It has been shown that the way to minimize errors caused by fluctuations in line resistance is to use high-resistance indicators. For good results, with any millivoltmeter, it also is often advisable to take care of gradual increases in the line resistance which show up in service. One obvious way is to measure the line resistance from time to time with a Wheatstone bridge, and to correct faulty conditions as they are thus detected. This method is used in many plants where, by means of portable test sets, lines are frequently inspected and kept in good condition, making it possible to use low-resistance indicators year after year quite satisfactorily. This, however, is not "compensation." There are two methods of compensation, the second being a development of the first:

(1) Using an adjustable series resistance. Indicators are made up with such rheostats and calibrated with the resistance at its maximum value. The adjustable resistance is reduced from time to time as the line resistance increases—such increase being determined by a portable test set.

(2) The Harrison-Foote method. This device obviates the need of a separate test set by a built-in arrangement of resistances, one of which is adjustable and in series with the line and moving coil, and is set at its maximum value when the indicator is calibrated. The arrangement is such that when the instrument is used for the first time the series resistance can be adjusted by seeing that the pointer reading is the same with a push button (or key) open or closed; and thereafter, as the line resistance increases, this series resistance is reduced from time to time—the adjustment being conveniently made the same way by seeing that the readings are the same with the key open or closed. This device is useful for multiple installations of different line resistance, as many series rheostats being used as there are thermocouples, and each being adjusted from time to time in the manner described.

Cold Junction Compensation—Any variation in the cold end temperature will cause a corresponding error in the indication of the hot junction temperature. As with the line resistance question (which is less serious) we can do two things: take care of the cold end by keeping it at a constant temperature, or let it fluctuate but compensate for variations.

To keep the cold end at a constant temperature it must be moved away from the terminal head of the couple mounting (by extending the thermocouple as explained above) to where we can locate it at will. There are several ways of keeping it within a couple of degrees plus or minus. For checking and testing purposes in the plant, as well as for scientific work in the laboratory, a thermos bottle filled with cracked ice is best, for it gives the "ice-point reference junction" within a fraction of a degree and makes possible precision work with the most accurate tables and charts. For most production work (outside of heat treating, certain refinery applications and other exact processes) the cold end may be buried—down a pointed pipe driven 10 ft. into the ground. Thermostat-controlled boxes are also in use. None of these methods, however, despite the text books, is real "compensation." There are two distinct methods of compensation—manual or automatic.

(1) Manual compensation, used when the cold end is brought to the indicator, is usually called "zero setting." The circuit is opened, the pointer is set to read the temperature of the instrument, and the circuit closed for work. The instrument is at the room temperature (except when

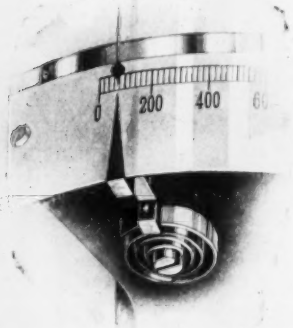


Fig. 24. Bi-Metallic Coil Thermometer by Means of Which Millivoltmeter Pointer is Initially Set. (*Brown Instrument Company*).

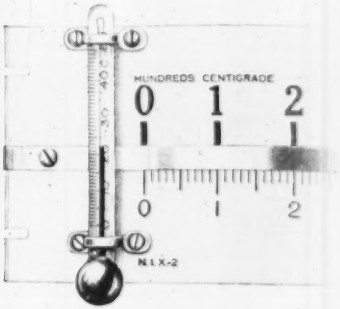


Fig. 25. To Aid in Setting For Temperature of Cold Junction Located in Instrument Case, Scale Makers Supply, on Request, A Thermometer Scale as The One Shown. (*Taylor Instrument Companies*).

carelessly located) but in order to eliminate guesswork a simple thermometer may be embodied in the indicator, as illustrated in Figs. 24 and 25, the former showing a device which saves close examination of the scale: you just set the millivoltmeter pointer opposite the bi-metallic thermometer pointer.

(2) Automatic compensation is obtained in many different ways in the laboratory, but in the plant there are three important methods: (a) mechanical, (b) electrical and (c) magnetic.

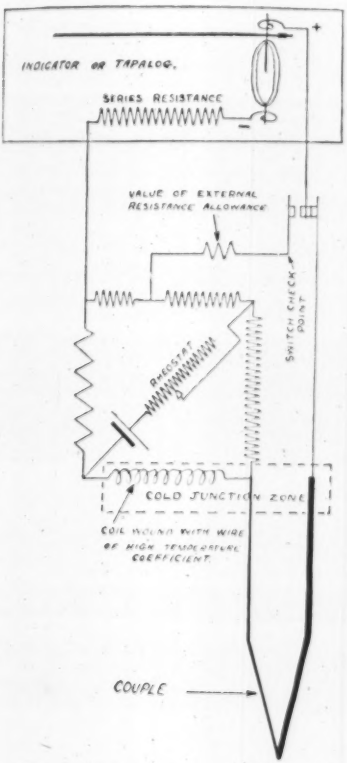
(a) Fig. 24 suggests a simple mechanical automatic method: letting a bi-metallic spiral move the pointer. As a matter of fact the Brown indicator has such a spring, which may be seen in Fig. 38 (top—where arrows H and I would meet if prolonged) as a white spiral with its outer end bent down where the hairspring is attached to it. This method, introduced by the Bristol Company, is used in several makes, and is most effective when the thermostatic coil compensates not only for the cold junction temperature but also for the variations in the resistance of the millivoltmeter moving coil (especially when such coil has a high resistance and is made of copper, which has a high temperature coefficient).

(b) Unlike the electrical method of compensation for line resistance, which requires manual operation, the electrical method for cold end temperature compensation is fully automatic. Fig. 26 is a diagram of the Wilson-Maeulen Wheatstone bridge compensator. Three sections of this bridge are resistances composed of materials of constant resistance. The fourth section is of material having a definite and exact change of resistance in proportion to change in temperature of this coil. The resistance changes of this compensating coil alter the relationship between the sections of the bridge, causing the current from a dry cell battery, connected across the bridge, to correct the thermocouple emf electrically in accordance with the changes of the cold junction. This temperature-responsive coil and the cold end are both located at the instrument, where both are subject to the same temperature changes. A rheostat in the battery circuit adjusts the battery current to exactness, and a convenient switch connection permits checking of the rheostat adjustment, using the pyrometer millivoltmeter to measure the battery adjustment to a check point on the scale.

(c) The magnetic shunt automatic method is ingenious: just a small block of iron on a thermostat spring which brings it closer to or farther from the poles of the instrument magnet as the temperature varies, affecting the strength of the field and hence the effective torque of the coil. Such a simple device is incorporated in the Roller-Smith Company's "miniature indicator" shown in Figure 41.

With or without cold junction compensation it is always necessary to keep the two connections, which make up the cold end, at the same temperature. A temperature differential between the two binding posts will cause a corresponding error in the indication—for in effect it creates a new thermocouple.

Another point to remember is that where the indicator is exposed to heat radiation from a furnace, the terminals, if they are not enclosed in the instrument case, may be at a much higher temperature than the inside of the instrument where the automatic compensator is installed.



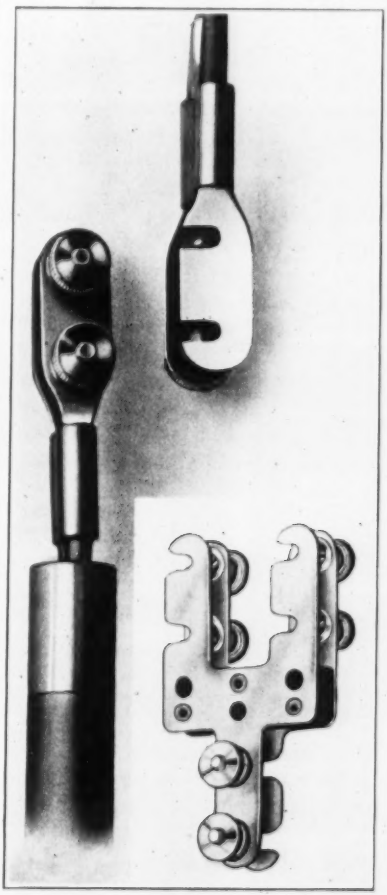


Fig. 26 (above). Electrical Method of Cold-Junction Compensation (Wolson-Maeulen Company).

Fig. 27 (right). Purposely Shown Here Twice as Large as in Maker's Own Catalogue—To Catch Eye And Emphasize Importance of Good Contacts in Pyrometry. Special Connections For Thermocouples. (*The Bristol Company*).

The Potentiometer Circuit—(The hasty reader turning at once to this page is advised to turn back to the heading "The Millivoltmeter Circuit" and at least glance through those pages, because the subjects applicable to both types of circuits will not be repeated here.) For precision work the potentiometer is greatly preferable to the millivoltmeter. First, it is much more sensitive. But even more important, the potentiometer method makes it possible to measure the emf developed by the thermocouple, quite regardless of variations in circuit resistance, length of leads, and other electrical conditions which may seriously affect the reliability of millivoltmeter indications, especially after months of severe industrial service.

Contrary to popular belief, the potentiometer circuit is not too complicated to be understood by any engineer who knows Ohm's law. It is simply a bridge circuit in which an unknown emf is opposed to a known emf, standardized by means of a standard cell, and resistances adjusted until there is *no flow of current at all at the moment of measuring*. (This applies only to the true null-method potentiometer. In a deflection potentiometer a part of the emf is unbalanced, and measured in the usual way by its effect on a moving coil).

Now consider what this means in thermoelectric pyrometry. Say we have a 30″ rare-metal couple. We want to measure the *uniform* temperature of a furnace. A millivoltmeter may read 20°F higher when the thermocouple is immersed a few inches than when it is immersed all the way the reason being the increased resistance of the thermocouple wires which form part of the circuit. Industrially, 20°F is "plenty accurate" at high temperatures, but with a potentiometer there can be no difference in the two indications.

Industrial potentiometer *indicators* cannot give continuous indications unless the same *mechanism* which accomplishes the balancing in the recorder or automatic controller is used. (These mechanisms will be dealt with in Parts 4 and 5 of this chapter.)* In all the world there are only two makes of industrial potentiometer pyrometers, both of them American. One is the Leeds & Northup; the other the Wilson-Maeulen. Leeds & Northup Co. has brought out an indicator which can be used by itself without a recorder or a controller. The instrument is shown in Fig. 22. In order to read the temperature, however, it is necessary to balance the circuit by means of a knob. The Wilson-Maeulen Co. has brought out a self-balancing indicator, but it is embodied in that Company's control unit. Thus there is no such device on the market as a self-balancing potentiometer indicator. The reason is simple—the cost of the additional mechanism may as well be applied to meet most of the cost of a recorder or of a control unit.

Now as to the hair-splitting: For laboratory work there is an important distinction between a true null-method potentiometer and a deflection potentiometer. The true null-method requires that no current flow at the moment of measurement. But in order to balance the circuit we require a galvanometer. Let us then call the galvanometer a millivoltmeter or microvoltmeter (which it is) and calibrate its scale in degrees and fractions. Now we have the deflection potentiometer. True, a very tiny current will flow

*The next installment of this Handbook will end Part 3 of the Temperature chapter (II) and will cover Radiation and Optical Pyrometers. Part 4 (Recording Temperature Instruments, both thermometers and pyrometers) will be published in June. The July installment will be Part 5, Automatic Temperature Control.

in order to deflect the pointer one way or the other, but although we drop strict scientific precision we obtain convenience: quicker readings.

Essentially, the circuits of all potentiometers are much alike. The "opposing emf principle" is always the same. The following description is of the Leeds & Northup circuit.

Fig. 28 shows the wiring of the potentiometer in its simplest form. The thermocouple is at H, with its polarity as shown by the symbols + and —. It is connected with the main circuit of the potentiometer at the fixed point D and the movable point G.

A current from the dry cell BA is constantly flowing through the main, or so-called potentiometer circuit, ABCDEFG. The section DGE of this circuit is a slide wire, uniform in resistance throughout its length. The temperature scale is fixed to this slide wire. The current from the cell BA as it flows through DGE sets up a difference in potential between D and E. There will also be a difference in potential between D and all other points on the slide wire. The polarity of this is in opposition to the polarity of the emf of thermocouple which connects into the potentiometer at D and at G. By moving G along the slide wire a point is found where the potential between D and G in the slide wire is just equal to the emf generated by the thermocouple. A galvanometer*in the thermocouple circuit indicates when the balance point is reached, since at this point the galvanometer needle will show no deflection.

The potential in the slide wire will vary with the current flowing through it from the cell BA and a means for standardizing this is provided. S. C., Fig. 29 is a Weston type standard cell whose voltage is constant. It is connected to the potentiometer circuit at two points D and F by closing the contact shown between S. C. and Galv., whenever the potentiometer current is to be standardized. The galvanometer is then in series with S. C. The variable rheostat R is then adjusted until the current flowing is such that, as it flows through the slide wire DGE and the standard resistance EF, the fall in potential between D and F is just equal to the voltage of the standard cell S. C. At this time the galvanometer will indicate a balance in the same way as when it was used with a thermocouple. By this operation the current in the slide wire DGE has been standardized. The standard cell is then disconnected and the thermocouple connected by closing the contact shown between Galv. and the + side of H.

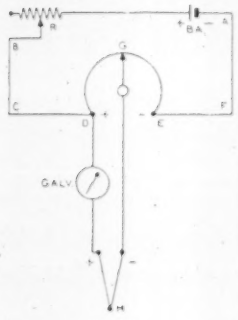


Fig. 28

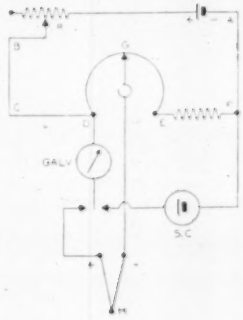


Fig. 29

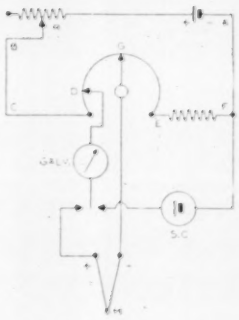


Fig. 30

Automatic Cold Junction Compensation. To correct for the temperature of the cold end, the potentiometer may have either of two simple devices. In one form the operator is required to set a small index to a point on a scale corresponding to the known cold junction temperature, as explained above under the millivoltmeter circuit. In the other form, an even more simple automatic compensator is employed. The principle of each is described in the following paragraphs (Leeds & Northrup):

As previously explained, the emf of the thermocouple is measured by balancing it against the potential DG in the slide wire of the potentiometer. As shown in Fig. 29, the magnitude of the balancing potential is controlled by the position of G. Make D movable

*Similar to a millivoltmeter, of course. The terms are sometimes used indifferently. In pyrometry it is not amiss to distinguish between an instrument which *measures* and one which *detects*.

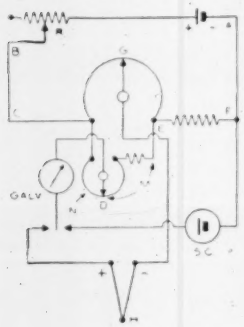


Fig. 31

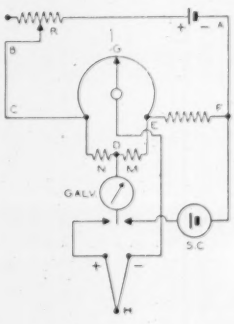


Fig. 32

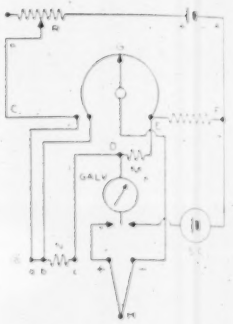


Fig. 33

as shown in Fig. 30, and the magnitude of the potential DG may be varied either from the point D or the point G. This gives a means for compensating for cold junction changes by setting the slider D. As the cold junction temperature rises, the net emf generated by the thermocouple decreases, assuming the hot junction temperature to be constant. To balance this decreased emf the slider D is moved along its scale to a new point nearer G. In other words, the slider D is moved along its scale until it corresponds to the known temperature of the cold junction, and then the potentiometer is balanced by moving the slider G. The readings of G will then give the temperature of the hot junction directly.

The same results will be otained if another slide wire upon which D bears is placed in parallel with the slide wire of G, as shown in Fig. 31. It is such a slide wire, with a temperature scale fixed upon it, that forms the manually operated cold junction compensator.

It should be noted that the effect of moving the contact D, Fig. 31, is either to increase N and decrease M, or to decrease N and increase M; in other words, the ratio between N and M is varied. In Leeds & Northrup indicators and recorders employing the automatic cold junction compensator, the ratio of N to M is varied automatically, in the following manner:

The point D, Fig. 32, is mechanically fixed; on one side of D is the constant resistance coil M, on the other the nickel coil N. N is placed at or near the cold junction of the thermocouple. Nickel has a high temperature coefficient (that is, its resistance changes about .25 per cent for every degree F.) and the electrical proportions of M and N are such that the resistance change of N, as it varies with the temperature of the cold junction, has practically the same effect upon the balancing potential between D and G that the movement of the point D has in the hand operated compensator of Fig. 31.

Fig. 33 shows a modification of Fig. 32 to meet the condition where the cold junction of the thermocouple is to be located at some point distant from the measuring instrument.

Two obstacles have stood in the way of a more extensive adoption of potentiometers in industrial plants. First, the name, which has deterred practical men because it suggests the laboratory. Second, the higher cost of the installations. Both of these obstacles are tending to vanish before the march of progress.

It must not be inferred that potentiometer pyrometers will ultimately drive out millivoltmeters. The latter in their convenient, inexpensive and satisfactorily accurate modern forms, serve an increasing number of applications in industry where the greater initial cost of the potentiometer is not justified. However, on all applications where the emf is small and where variations in external circuit resistance cannot be avoided, the potentiometer should be adopted without hesitation whenever a consideration of the financial value of accurate temperature work justifies its installation.

Thermocouples

There is a trend toward standardization in that a few industrially successful thermo-*elements* emerge as industry's favorites while others are relegated to unusual applications. But when it comes to the mechanical construction of *mountings* and *accessories*, variety grows greater with almost every new catalogue. On the whole this is a healthy situation:

(a) Very little choice of *elements*, so that users need not buy headache powders when faced with making a decision;

(b) A pleasantly wide choice of *constructions* for all important applications—illustrated and described as well as priced;

(c) A growing number of "specials," each made to order for some industry or *standardized* piece of equipment. (These include complete indicating systems, quantity-built and assembled, and consisting of thermocouple, cable and millivoltmeter indicator—all "ready to use").

Thermo-elements—About fifteen years ago the vogue began of listing in great detail the ideal specifications of thermocouples. This is like describing the ideal tool-maker or oil-refinery superintendent: "Try and find him." With pyrometers you must generally take what you get . . . and like it! The reason is that every conceivable pair of metals and alloys has serious limitations as well as definite advantages. In the laboratory you can select any two materials, work out a circuit, handle the cold junction and calibrate an indicator for use with that one particular couple and

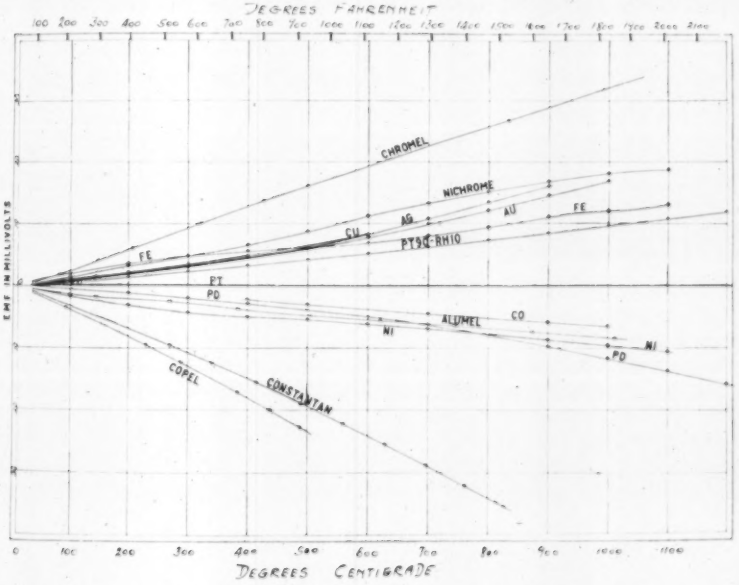


CHART I—EMF'S OF VARIOUS MATERIALS VERSUS PLATINUM, AT DIFFERENT TEMPERATURES, COLD JUNCTIONS AT 0°C, (32°F).

(Adapted from original chart published by Bur. of Stds).

From this chart the emf of any couple is found by measuring the vertical distance between the two curves for the two chosen materials, the upper curve indicating the positive element. Thus at 500°C the emf of a copel-platinum thermocouple would be 23.4 millivolts, copel being the negative element, while at the same temperature a platinum-chromel couple would develop 16 millivolts, chromel being positive to platinum and hence also positive to copel. The emf of a copel-chromel would be 16+23.4 millivolts at 500°C. Where two curves are parallel in a given temperature range the emf of a couple made of the materials indicated would remain constant throughout that range. Where two curves cross, the emf of the couple indicated would decrease, become zero, and then increase in the reverse direction as the temperature is varied uniformly through this range, provided the cold junctions are at the ice point.

TABLE III. PRINCIPAL CHARACTERISTICS OF ELEMENTS COMMONLY EMPLOYED IN INDUSTRIAL THERMOCOUPLES ON THE MARKET

(Exclusive of temperature-emf relations)

Couple	RARE-METAL	BASE-METAL			
	Pt	Copper	Chromel X	Iron	Chromel
	Pt-Rh	Constantan	Copel	Constantan	Alumel
Lowest temp. for satisfactory results (1)	0°C 32°F	Approx. −200°C −400°F	Approx. −200°C −400°F	Approx. −200°C −400°F	Approx. −200°C −400°F
Highest temp. for good results BARE couple in air	1450°C 2650°F	350°C 660°F	550°C 1020°F	850°C 1560°F	1200°C 2190°F
Highest temp. for good results BARE couple in molten metals	———	———	———	750°C 1380°F	1150°C 2100°F
Highest continuous temp. for good results, usual protection (2)	1400°C 2550°F	350°C 660°F	550°C 1020°F	850°C 1560°F	1200°C 2190°F
Reproducibility (3)	Good	Depends on Supply	Good	Depends on Supply	Good
Resistance to Corrosion	Perfect	Fair	Good	Fair	Good
Resistance to Oxidation	Perfect	Fair	Good	Fair	Good
Standard diameters of wires	B. S. Gage 24	B. S. Gages 36 to 2	B. S. Gages 22 to 2	B. S. Gages 22 to 2	B. S. Gages 22 to 2
Cost of best wires	Approx. $2.00 per inch of No. 24 Gage Couple	Approx. $1.00 per lb.	Approx. $2.50 per lb.	Approx. $1.00 per lb.	Approx. $4.00 per lb.
Especially useful for	Standards and Precision Work	Low Temperature	Oxidizing Atmospheres		
Not recommended for	———	———	Reducing Atmosphere		

(1) Thermocouple tip being measuring junction; and usual "cold" junction being the "reference" junction—in this case the hotter of the two.

(2) Temperature of the elements—not necessarily temperature to be controlled. See text.

(3) Reproducibility or interchangeability—Uniformity of electrical characteristics in order that a number of couples may successively be connected to one instrument without affecting accuracy of successive indications on one scale.

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circuit; in the plant this procedure violates all canons of scientific management. Interchangeability is the great essential for production work, and the chances are a hundred to one against unusual elements being so reproducible that the instrument scale will not need re-calibration. The elements on the market are standardized and almost perfectly interchangeable within each type (See Table III). The commercial indicators have scales graduated in degrees of temperature and read correctly for one particular type of thermo-elements, generally made by the same manufacturer. Every "pyrometer problem" within the limitations (range, etc.) of the industrial instruments can be taken care of. Why experiment?

The thermo-elements on the market are as follows:

Rare-metal—Platinum *versus* platinum-rhodium, the alloy being 90% Pt. and 10% Rh. (Le Chatelier) or 87% Pt. and 13% Rh. (Engelhard). Iridium, palladium and other noble metals are no longer used industrially.

Base-metal—Ninety percent or more are iron-constantan, chromel-alumel, copper-constantan or chromel-copel. Other combinations are giving satisfactory service and there is no intention to recommend against their use, but lack of space restricts discussion to the "big four" just mentioned, the characteristics of which are thoroughly known by the makers of indicators.

Scientific literature goes into lengthy discussion of thermo-elements. The characteristics of interest to the engineer fall into two classes: (1) The millivolt curve, or temperature-emf relation. This is given in Chart I. (2) Other characteristics. The principal ones of these are given in Table III. This table embodies information lately obtained from the most authoritative non-manufacturing sources, and hence is somewhat conservative, in the opinion of the author of this Handbook who therefore, in order to present the manufacturers' findings, includes here an abbreviated (but not otherwise altered) statement by Charles Engelhard, Inc.:

Platinum vs. 90% Platinum, 10% Rhodium—Standard diameter .0236" (6 mm). Other diameters .020" (.5 mm); .0157" (.4 mm) and smaller sizes to order.

This thermo-element is recommended for temperature measurements up to 1600° C. (2900° F.) Interchangeability from element to element and from lot to lot is guaranteed within limits of 3° C. (5° F.).

A particular point should be made as to the difference in serviceability between a 10% rhodium thermo-element and one having a higher percentage of rhodium in its alloy wire. It has been definitely established that the 10% alloy is the most refractory and the most reliable. This type developes an e. m. f. of 16.90 M. V. at 1600° C., and an e. m. f. of 10.64 M. V. at 2000° F.

Chemically, a platinum and platinum-rhodium thermo-element is very much less active and more stable than base metal thermo-elements.

Theoretically, therefore, they should hold their calibration better than base metal types even without gastight protecting tube. Notwithstanding the fact that platinum is a very stable metal, there are few conditions where gastight protecting tubes cannot be used to advantage.

This thermo-element has long been recognized as the standard throughout the world. While the first cost of this type of thermo-element is several times more than for one of a base metal of the same length, it should be remembered that the life of the first can be figured in years as against months or weeks for the second. One of the largest industrial plants in America that has several hundred furnaces equipped with our 10% rhodium couples doing heat-treating work of all kinds, has a maintenance cost averaging around $3.50 per furnace per year. This covers renewals of platinum wire, protecting tubes, etc. Couples of this type are in service to-day that have been measuring temperatures averaging around 1800° F. for fifteen to twenty years.

On account of the cost of these thermo-elements and their long life, every precaution should be taken to give them all possible protection.

Platinum vs. 87% Platinum, 13% Rhodium—Standard diameter .0236" (6 mm.). Other diameters .020" (.5 mm); .0157" (.4 mm) and smaller sizes to order.

This wire is not quite as refractory as the 10% alloy but gives much better service than would be the case if it were less pure, because it holds its calibration better, and is slower to crystallize.

Iron-Constantan—Standard diameter No. 10 B. & S. gauge, other sizes to order.

This type of thermo-couple is recommended for use in temperatures not above 900° C. (1650° F.). Best service will be obtained from it when used in a neutral or reducing atmosphere.

With the quality of wire which we offer, interchangeability between different thermo-couples and from lot to lot is guaranteed to within limits of 5° C. (9° F.).

When these couples are properly protected against contamination there will be no trouble due to parasitic currents. The iron wire which forms one arm of the thermo-element is of the very purest iron obtainable.

The best service will be obtained when they are provided with a primary protecting tube of hard porcelain outside of which is used a metal secondary protecting tube to give the required mechanical protection. The cost of the primary tube will be offset by the greater permanence of calibration and the longer service which will be given by the wires before renewal is required. In case no porcelain primary tube is used, an iron protecting tube either plain or calorized is recommended. A protecting tube of other metal might act as a contaminating agent itself if the iron-constantan wires were directly exposed to its influence.

Chromel-Alumel—Standard diameter No. 8 B. & S. gauge. Other sizes to order.

This type of thermo-element is recommended for use in temperatures not above 1000° C. (1800° F.). Best service will be obtained from it when used in neutral or oxidizing conditions.

The interchangeability of chromel-alumel thermo-elements from element to element and lot to lot, is guaranteed within limits of 8° C. (15° F.). The somewhat lower degree of interchangeability of these as compared with the iron-constantan types is in part offset by the fact that they can be used for a little higher temperature range. Some manufacturers have recommended this type of thermo-element for temperatures even as high as 2000° F. or a little more. While this is possible for short periods of time, we recommend against using it at such high temperatures under continuous conditions, and where renewals cannot be easily made.

An improvement in the permanence of calibration as well as in the length of service which will be given by any one set of wires, will be obtained by using a primary protecting tube of hard porcelain inside of the usual metal secondary tube. This is particularly true when the couple will be used under slightly reducing conditions or in the presence of sulphur fumes.

In those cases where no porcelain primary tube is used, a secondary protecting tube of nickel-chromium alloy or pure nickel is recommended, rather than iron or calorized iron, for the latter may prove a source of contamination under certain conditions when the chromel-alumel wires with double-bored insulation are subjected to their influence without intervening gastight protection.

Copper-Constantan—This type of thermo-couple is recommended for accurate temperature measurements where the thermo-electric system is most convenient, and for a range not to exceed 200° C. (400° F.). This is considered to be the most accurate base metal couple developed up to the present time.

Interchangeability between different couples and from lot to lot can be guaranteed within limits of 5° C. On account of the purity of the metals going into this couple and the homogeneity of the alloy, a much higher degree of accuracy than this can be expected from any thermo-couple which is individually calibrated for precision measurements. Frequently this couple is used with multiple junctions, i. e., several thermo-couples in series, for very accurate temperature work in small areas where quick readings are desired.

Due to the low temperatures for which this couple is suitable, no primary or secondary protection other than insulation, is ordinarily required. When it will be used in acid fumes or under other corrosive conditions, a very thin wall transparent quartz glass tube or a very small protecting tube of hard porcelain can be furnished.

Conditions of Use of Couples—Having discussed thermo-elements and before passing on to protection tubes and mountings, a few miscellaneous notes on conditions of use in general:

The cold junction, as has been seen, is usually two junctions (metal X to brass, brass to metal Y). The same condition may apply to the hot junction. Its wires need not touch if they are immersed in molten metals, or in mercury. Remember this. There are many uses for a bare couple. For temperature of solid metal parts (bearings, etc.) the wires may be peened into the metal. In all such cases the two wires should be close together

because a difference of temperature at their respective entrance points will set up an additional emf. In all such cases, too, it should be noted that the surface temperature is the one which will be indicated. Welded or twisted couples dipping in slightly conducting liquids should not be immersed deeply because of leakage between the wires at other points than the junction. Moreover there generally will be likelihood of galvanic action — the same principle as that of a primary cell.

No need to stress the importance of thoroughly insulating thermocouple wires everywhere but at the junction.

Radiation and conduction effects may affect the accuracy of couples in air or gases. The couple will develop the emf due to its own temperature, but its own temperature may be different from that of the medium. Remember that the wires conduct not only electricity but heat. Where a high order of accuracy is desired, the couple should be surrounded by a sleeve

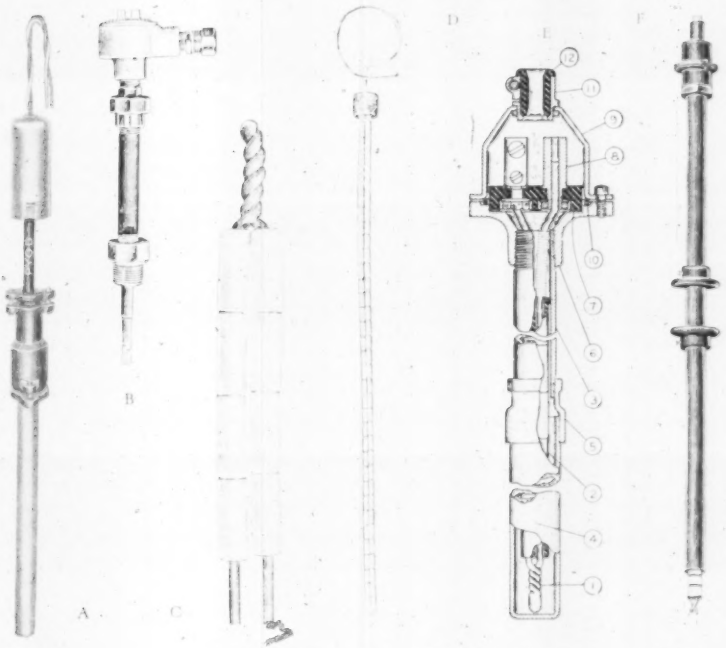


FIG. 34. INDUSTRIAL FORMS OF BASE-METAL THERMOCOUPLES.

A—Iron-constantan tube-and-wire couple (details in Fig. 35) in mounting for work up to 1700°F (when protecting pipe is of fernichrome) including stuffing box and weather-proof connection head. (*Wilson-Maeulen Company*).

B—For installation in pipe-lines, where it offers little obstruction, this form withstands 1000-lb. pressure. Iron-constantan elements, porcelain insulator, in ¾" steel tube welded to std. pipe bushing attached to 1½"x6" nipple with M & F union. Weather-proof head. (*Leeds & Northup Company*).

C and D—Iron-constantan wires (No. 8 B. & S. gauge) in porcelain insulators. Composition head with terminals attached. (*Leeds & Northup Company*).

E—Chromel-alumel elements (1), heavy-duty mounting. Cast nichrome protaty protection tube (4). For continuous duty to 2000°F, intermittent duty to 2200°F. Porcelain insulators (2). Porcelain base (7). Copper-asbestos gasket (10) makes couple suitable for outdoors. Bushing (12) is left out for conduit wiring, conduit being inserted instead. (*Taylor Instrument Companies*).

F—Bare couple, No. 8 B. & S. gauge iron and constantan wires in porcelain insulators mounted in opened ¾" extra-heavy w. i. tube with adjustable flanges. Enclosed head with terminals attached. For continuous duty to 900°F, intermittent duty to 1100°F. (*Leeds & Northup Company*).

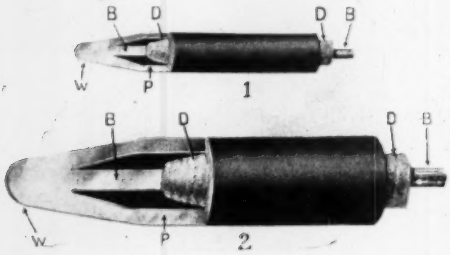


Fig. 35. Actual size part-section views of rugged yet sensitive couples consisting each of an iron tube P welded at W to a constantan wire B which is insulated by asbestos cord D. Larger size can be used bare up to 1000°F., smaller up to 800°F. (Wilson-Maeulen Company).

to prevent the junction "seeing" surfaces colder or hotter than the medium and giving or receiving radiation to or from such surfaces.

Arranging a number of hot and cold junctions in series will give the sum of the emf's; in parallel, the average; but resistance addition or division modifies the exactness of the theoretical values.

Industrial Forms of Assembled Thermocouples—The few illustrations (Figs. 34 to 37 and 43 to 47) convey but a slight idea of the variety. Reference was made above to "specials" which are really standard for some industrial processes. Among these are the following:

"Spark plug" couples comparable to short-stem pipe-thread connection thermometer bulbs and used for similar applications. Fig. 34B shows only one manufacturer's product. There is a satisfactory variety available.

"Mold" thermocouples with a very small contact area, especially useful for work with bakelite, etc.

For brass, bronze and aluminum foundries, thermocouples are made with unwelded elements at the end of convenient handles, which hold two spools—one for each wire. The life of the immersed ends is short but they are trimmed in a jiffy. There is no waste of time or material. There is also a heavy-wire non-reeling type, the advantage of which is longer life.

For high temperature work where reliability of indication is of greater importance than accurate measurement of temperature, and where it is desired to protect rare-metal thermocouples as much as possible, the final protection takes the form of silica blocks designed to be built into the crown of the furnace. (Fig. 47.)

Practically all manufacturers have an extensive line of flanges and other connections for use in attaching thermocouples to the various forms of industrial process furnaces and other equipment.

Surface-contact thermocouples are shown in Figs. 44 and 46. There are various other forms, including even one made by Taylor especially for hotel ranges.

Protecting Tubes—For high-temperature work these are of far greater *practical* importance than the thermo-elements. Except in pure air they are an absolute necessity. Everyone who knows what furnace gases do to even the best refractories should not expect pyrometer makers to produce miraculously resistant materials out of a silk hat.

The following properties (as listed by the Bureau of Standards) should be considered in reference to the particular process for which the tube is required:

(1) Low porosity to gases. Many tubes become very porous to furnace gases at high temperatures.

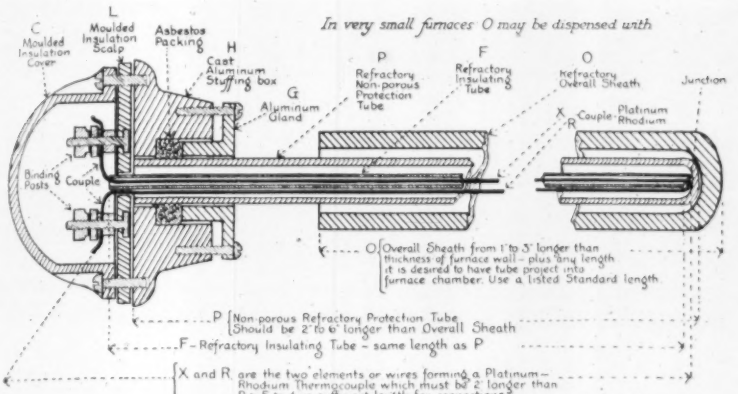

In very small furnaces O may be dispensed with
C
Moulded Insulation Cover
L
Moulded Insulation Scalp
Asbestos Packing
H
Cast Aluminum Stuffing box
G
Aluminum Gland
P
Refractory Non-porous Protection Tube
F
Refractory Insulating Tube
O
Refractory Overall Sheath
Junction
X
R
Couple Platinum Rhodium
Binding Posts & Couple
O Overall Sheath from 1" to 3" longer than thickness of furnace wall – plus any length it is desired to have tube project into furnace chamber. Use a listed Standard length.
P Non-porous Refractory Protection Tube Should be 2" to 6" longer than Overall Sheath
F – Refractory Insulating Tube – same length as P
X and R are the two elements or wires forming a Platinum – Rhodium Thermocouple which must be 2" longer than P or F, to give sufficient length for connections

Fig. 36. Sectional sketch of assembly of industrial high temperature rare-metal couple (Pt vs Pt 90%, Rh 10%) with its insulating and protecting tubes, overall sheath and zone box—the latter comprising parts C, L, H and G. (*Wilson-Maeulen Co.*)

(2) Low volatility. Certain metal tubes are undesirable at high temperatures because the metal distills upon the couple, thus altering its calibration.

(3) Ability to withstand high temperature.

(4) Ability to withstand sudden changes in temperature.

(5) Ability to withstand mechanical shocks and strains.

(6) High rigidity. Protecting tubes frequently deform and exhibit the phenomenon of plastic flow at high temperatures.

(7) Thermal conductivity. High thermal conductivity is frequently desirable when rapidly changing temperatures are measured. Usually, however, low thermal conductivity is desired so that the flow of heat along the tube be as small as possible.

(8) Ability to resist corrosion from molten metals or furnace gases.

A few notes on various types follow:

Seamless Steel tubes—up to 1400°F. Used for small diameter thermocouples and where thin wall metallic tubes are required for sensitivity.

Wrought Iron tubes—up to 1400°F. Flue gas temperatures; bake ovens; dryers, glass lehrs; asphalt mixers; molten aluminum. Suitable where extreme oxidizing atmospheres are not encountered and where an inexpensive protection tube is required.

Cast Iron tubes—up to 1400°F. Concentrated mineral acids.

Calorized Iron tubes—1500°F. Water gas plants. Resist oxidation better than wrought iron or steel tubes. Particularly suitable for flue gas temperature work, having a life three to twenty times that of wrought iron. Not recommended in case of alkaline reaction.

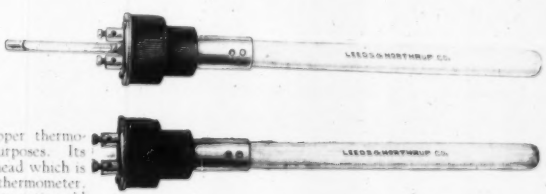


Fig. 37. Rare-metal thermocouples with gas-tight porcelain primary protection tubes. (In production work a secondary protection tube is generally required). The upper thermocouple is used for checking purposes. Its cold junction is in the terminal head which is provided also with a mercurial thermometer. The lower one is used with automatic cold junction compensation. The similar construction outside of the head makes it possible to use the checking couple to check a number of the others by substitution. (*Leeds & Northup Co.*)

Copper tubes—up to 1800°F. Chemical plants; manufacturing of acetic acid; steam pipes.

Chromel resists oxidation and is suitable between 1400 and 2000°F. These tubes are not to be used in a reducing atmosphere. This material is also suitable for lead pots. Chromel will last longer in an oxidizing atmosphere than in a reducing one, but will give as long a life as other metallic tubes under reducing conditions at 2000°F. Alternating reducing and oxidizing conditions are disastrous to chromel.

Nickel Chromium—up to 1800°F. Heat treating furnaces; water gas plants; lead baths.

Pure Nickel—up to 2000°F. Barium chloride and cyanide baths; also in oxidizing atmospheres.

Duraloy tubes can be used up to 2100°F. and satisfactorily resist oxidation. May be used for cyanide baths, galvanizing baths and for type metal.

Quartz—up to 2200°F. For thermocouples subjected to changes in temperature, but *not* to *sudden* changes in spite of printed statements.

Dialumite, Carbofrax and other super-refractories—up to 3100°F. (Even 3300° *furnace* temperature.) Glass tanks, etc.

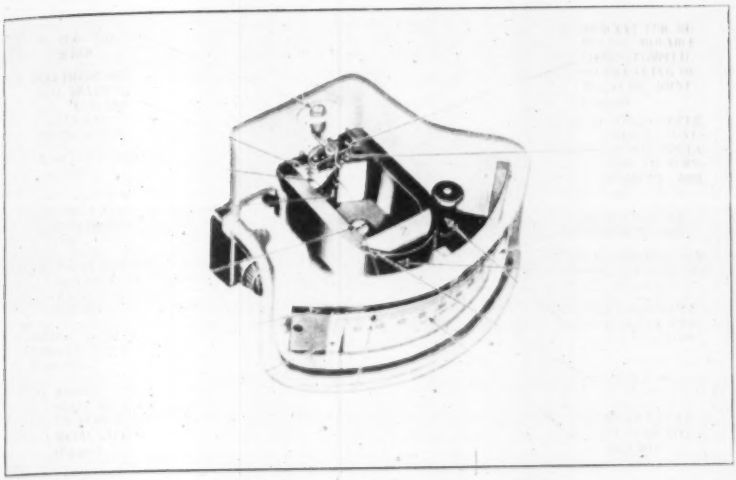
At this date (1930) it is not practicable to make up a table of characteristics for protection tubes along the lines of Table III. The user may safely leave this matter to any leading pyrometer manufacturer. (For a detailed discussion of this subject see the paper by Hutchins at the 1919 symposium of the A. I. M. M. E.) It must be borne in mind that against the combination of high temperature and corrosive atmosphere the primary protecting tube is not sufficient. *The secondary protection must be selected judiciously.* It is the *first* line of defense.

Indicators

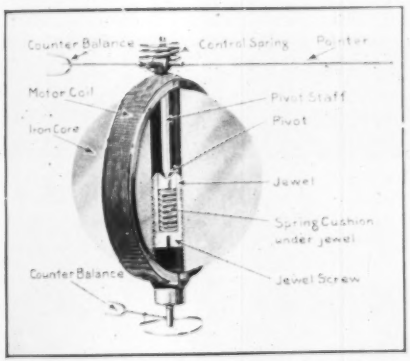
Depending upon the method of measurement of the thermocouple emf, the indicators are divided into two classes: Millivoltmeters, made not only by specialist manufacturers of industrial temperature instruments, but by most manufacturers of electrical instruments; and potentiometers, made only by Leeds & Northup and Wilson-Maeulen.

Low-resistance millivoltmeters are usually made up in the horizontal coil form, which means a dial or scale in a vertical plane.

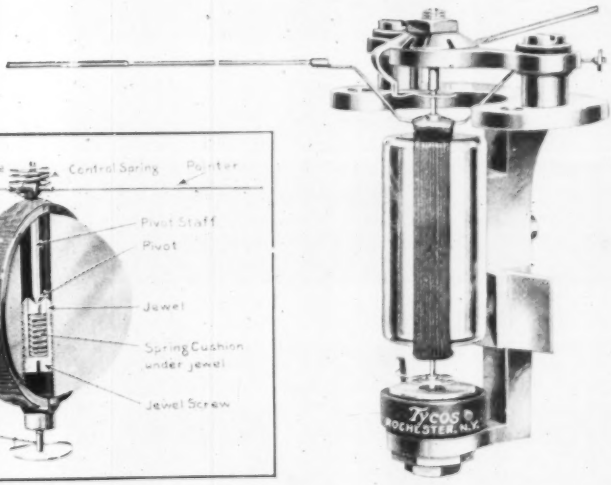
High-resistance millivoltmeters are *all* made up in the vertical coil form and most of them embody exquisite refinements which make them capable of withstanding industrial service conditions without impairment of intrinsic accuracy. Fig. 38 shows the details of three standard makes. The general construction of such instruments is interestingly shown in the upper "phamton view" of the Brown instrument. The Wilson-Maeulen indicator is characterized by a single pivot moving system which is self balancing. The Taylor high-resistance indicator movement is shown in its actual size. The Republic indicator is shown only in an outside view in Fig. 39. Its movable element assembly is supported in a bronze die casting which slides into an aluminum die casting, the latter receiving the magnet and locating the pole pieces. The Englehard movement is interesting in that the moving system is supported by ribbon-like metallic filaments at the top and bottom of the moving coil. These filaments take the place of pivots, hairsprings and leads. The Englehard moving coil is wound without frame, which cuts down the weight.



(Brown Instrument Co.)



(Wilson-Maeulen Company)



(Taylor Instrument Companies)

Fig. 38. Special Construction Features of Millivoltmeters Made For Use as Thermoelectric Pyrometer Indicators. (See text).

Lack of space prevents illustrating and describing other millivoltmeter indicators on the market which are likewise triumphs of the instrument makers' art.

Just one word of advice in connection with specifying millivoltmeters. Don't order or accept an indicator scaled up to the highest temperature at which the couple can be used if it is not to be used on work anywhere near this maximum. It will not be as sensitive as one with a lower range. Some

low-priced instruments (which are splendid contributions to industrial progress because they popularize high-temperature measurement) are offered for use at temperatures far below their limit. In such cases, take the earnest salesman's claims with a grain of salt. The best working range of *any* moving coil electrical measuring instrument is between 60% and 85% of its maximum.

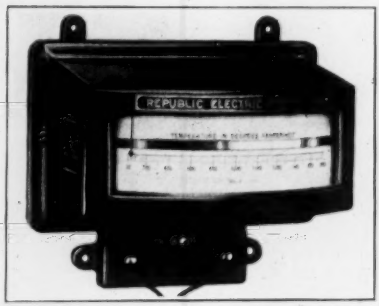


Fig. 39 (*above*). Vertical-coil indicator of very high resistance (*Republic Flow Meters Company*).

Fig. 40. (upper right). Horizontal-coil medium-resistance indicator. (*The Bristol Company*).

Fig. 41 (*below*). 4" diam. indicator direct-connected to couple by flexible cable. (*Roller-Smith Company*).

Fig. 42 (*lower right*). Panel assembly with high-resistance indicator and multiple-switch. (*Wilson-Maeulen Company*).

INDUSTRIAL MILLIVOLTMETER PYROMETER INDICATORS

Fig. 43 (*left*). The "Thermopyte" portable immersion pyrometer for occasional checking up to 2200°F, weighs only 4½ lbs. with 39" stem. (*Taylor Instrument Companies*)

Fig. 44 (*below*). Special shape couple for mill rolls, glass cylinders, etc. To save wear, this unit is often fastened to a rod in such a way that it may be pressed against the roll only when it is desired to read the indicator. (*Taylor Instrument Companies*).

Fig. 45 (*right*). Designed for molten type metal and other similar applications, this semi-portable self-contained pyrometer has an aluminum-cased indicator provided with an adjustable bracket, and the thermocouple is renewable. (*Taylor Instrument Companies*).

SPECIAL INDUSTRIAL THERMOELECTRIC PYROMETERS

Troubles

Among common causes of slight or serious pyrometer troubles there may be noted the following (some of which do not apply to potentiometers):

First and foremost—*Poor Connections*—loose, corroded, oily, dirty, etc. etc.

Next—Short-circuits inside thermocouple stem caused by worn or broken insulators. Then:

Locating instruments too near sources of heat. Even with automatic compensation of cold junction in instrument case, this is poor practice. Such compensation may not be designed to take care of serious increase in coil resistance (and hence lower torque) due to excessive head temperature. It *cannot* take care of the actual connections (the real cold end) being hotter than the inside of the indicator.

Locating instruments where they are subjected to excessive vibration and shocks. Even one sudden jar may cause two or more turns of a spiral spring to catch one another. Same effect as shortening spring, which opposes coil: Readings will be too high.

No extra protection from excessive dust, fumes and moisture.

Altering length and resistance of extension and even of copper leads.

"Repairing" broken or worn extension leads with unsuitable wires. May cause an error of more than 15% with some millivoltmeter indicators.

Even in replacing leads with properly chosen new leads, reversing polarity will cause serious errors.

Various unforeseen causes of change of resistance of leads. For instance, hanging leads over widely spaced hooks or beams will make them stretch by their own weight.

Running leads close to furnaces, etc. for long distances.

Neglecting to check with open circuit.

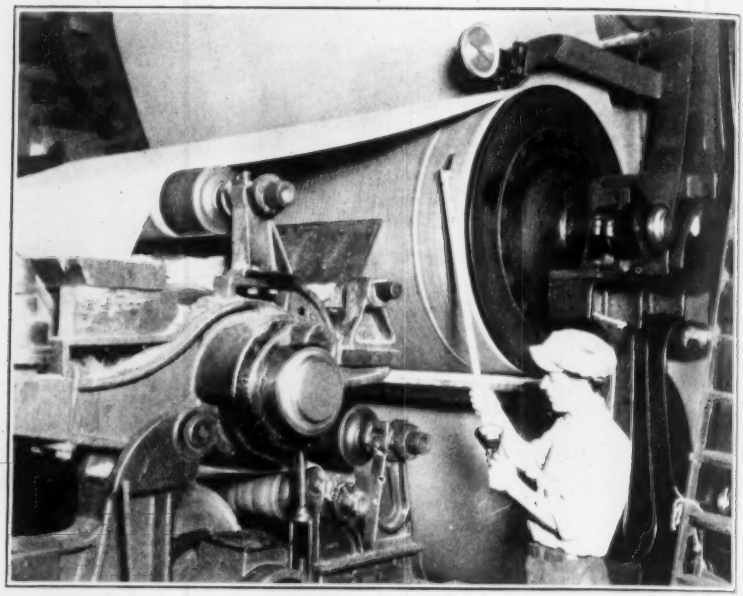


Fig. 46. Portable surface pyrometer with flexible thermo-element with weld half-way between the ends. Extension form. (*Cambridge Instrument Company*).

Neglecting to inspect buried cold junction by lowering a minimum registering thermometer tied to a string, which should be done once each season.

Neglecting to inspect thermostated junction or zone boxes.

Neglecting to test contacts of multiple and other switches.

Variable immersion of long thermocouples.

Allowing ashes, dust, clinkers or other material to accumulate on the end of the protection tube.

Using instruments scaled for one pair of elements to measure temperature by the emf produced by a pair of different elements (other metals or alloys).

Impairment of homogeneity of thermocouple wires where exposed to temperature gradients (Reason: new Thomson emf). Such impairment is usually caused by contamination (cracked protection tube, etc.) but it may be caused by sharp bends in new thermocouple wire.

Induced currents, stray leakage, etc. Wherever there are electric furnaces, electrical machinery or even the usual plant wiring, in the close vicinity, the original installation should be made by a trained man. This is especially true of multiple switching circuits.

Galvanic effects arising from worn insulation plus moist wood, etc., between leads.

The "Becquerel effect", set up sometimes when tubes are not gas-tight and themselves emit a gas which contaminates the couple. For example, silicon on platinum: an additional thermocouple is created. Generally remediable by annealing the wire.

Finally—If the pointer wobbles, there is trouble somewhere—probably a loose connection or defective insulation. Easily located by shaking one part of the circuit after another.

Checking Procedures and tables of fixed points will be found in the Appendix.

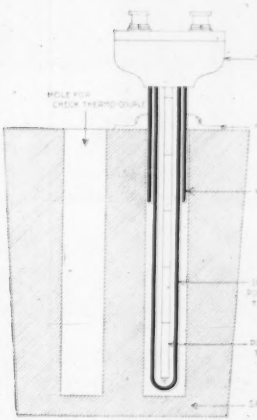


Fig. 47

Measurement of Air Flow

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CHAPTER IV—*(Continued)*

Stream-Line Flow in Pipes.—Let us imagine a fluid flowing along a straight parallel pipe under the influence of viscous forces only. If we consider any cylindrical element AB (Fig. 19) of the fluid, coaxial with the pipe, we see that there will be a viscous drag, which opposes the motion, acting on the cylindrical surface, and for the motion to proceed steadily this drag must be balanced by the difference in the pressures acting on the two ends A and B.

Let the length of the cylindrical element be dl and its radius r, and let R be the radius of the pipe.

Since the motion is assumed to be parallel to the walls of the pipe, there are no viscous forces acting radially and therefore the pressure across any section perpendicular to the axis is uniform. We may therefore denote by p the pressure on the face A, and that on B by $p - dp$. The pressure difference

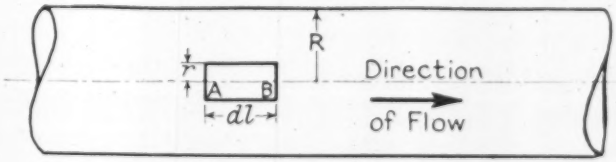

FIG. 19.

maintaining the motion is therefore $\pi r^2 dp$, and this must be equal to the viscous retarding force acting on the curved surface of the cylinder, which, from the definition of the coefficient of viscosity μ, is $2\pi r dl \mu \frac{dv}{dr}$, where v is the velocity at radius r.

Hence

$$\pi r^2 dp = -2\pi r dl \mu \frac{dv}{dr}, \quad \text{or} \quad \frac{dp}{dl} = -\frac{2\mu}{r}\frac{dv}{dr}.$$

Now the velocity will be some function of the radius only, since μ is constant and the flow is continuous and parallel to the walls of the pipe. In the above equation, therefore, the

* *Proc. Roy. Soc.*, 1911, A., vol. 85, p. 366.

right-hand side is a function of r only, and since the pressure does not vary across the section it follows that $\frac{dp}{dl}$ is a constant for given conditions of flow. We may therefore write $\frac{p_1 - p_2}{l}$ for $\frac{dp}{dl}$, where p_1 and p_2 are now the pressures at two sections at a finite distance l apart ; i.e.

$$\frac{p_1 - p_2}{l} \cdot rdr = -2\mu dv,$$

and, on integration between $r = 0$ and $r = R$, we have

$$\frac{p_1 - p_2}{l} \cdot \frac{R^2}{2} = -2\mu(v_R - v_a), \quad . \quad . \quad (7)$$

where v_a is the velocity at the axis.

If we assume that the velocity is zero at the walls,

$$v_R = 0,$$

and

$$\frac{p_1 - p_2}{l} = \frac{4\mu v_a}{R^2} \quad . \quad . \quad . \quad . \quad (8)$$

The velocity at any radius r is obtained from (7) by substituting r for R and inserting the value of v_a from (8), and will be seen to be given by

$$v_r = \frac{p_1 - p_2}{4\mu l}(R^2 - r^2), \quad . \quad . \quad . \quad (9)$$

from which it appears that the velocity distribution is parabolic across the section.

The mean velocity is obtained as follows :—

Imagine an annulus of the pipe at a radius r and of thickness dr ; the volume of fluid flowing through the annulus is given by $2\pi r dr v_r$, where v_r is obtained from (9). The total volume flowing is therefore

$$V = \int_0^R 2\pi r v_r dr = \frac{\pi(p_1 - p_2)}{2\mu l}\int_0^R r(R^2 - r^2)dr$$

$$= \frac{\pi(p_1 - p_2)}{2\mu l}\left[\frac{r^2R^2}{2} - \frac{r^4}{4}\right]_0^R = \frac{\pi(p_1 - p_2)R^4}{8\mu l}.$$

Now the mass of fluid passing in unit time is obviously constant, and if the pressure drop is small compared with either p_1 or p_2 (which are usually, of course, approximately atmos-

pheric) we may, in the case of a gas, neglect changes of density and regard the volume flowing in unit time as constant. In the case of liquids, which are practically incompressible, this will be so even if the pressure drop is large. In either case, therefore, the volume flowing in unit time may be taken as constant and equal to $\pi R^2 v_m$, where v_m is the mean velocity of flow.

Hence

$$\pi R^2 v_m = \frac{\pi R^4 (p_1 - p_2)}{8\mu l},$$

or

$$v_m = \frac{p_1 - p_2}{8\mu l} R^2. \quad . \quad . \quad . \quad (10)$$

Now (8) may be written

$$v_a = \frac{p_1 - p_2}{4\mu l} R^2.$$

In stream-line flow, therefore, the mean velocity of flow is half the velocity at the axis.

The Resistance of a Pipe of Varying Cross-section.—It has been shown that the resistance of any given length of pipe is equal to the loss in energy experienced by unit volume of the fluid in passing along this length. When the pipe is parallel between the two sections considered and the velocity distributions at these sections are the same, we have seen that the resistance is equal to the difference of static pressure between the sections; but if the diameters of the two ends of the length of pipe are not the same the resistance is equal to the difference between the mean energy of unit volume of the fluid at the two sections. The same is true for a parallel pipe in which the velocity distributions at the two ends are not identical. In the general case we have therefore to measure the mean energy per unit volume, i.e. the mean total head, at the two sections and to subtract one from the other. This may be done as follows :—

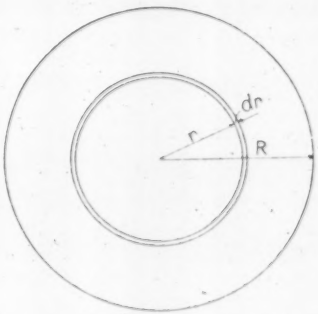

FIG. 20

Consider any section of the pipe of radius R, and let v be the mean velocity at radius r through an annular element of width dr. Also let p be the static pressure at this radius (p is taken above or below atmospheric pressure in the usual manner). The volume of fluid passing through the annulus in unit time is $2\pi r dr v$; its mass is therefore $2\pi r dr . \rho v$, and its

kinetic energy $2\pi rdr \cdot \rho v \cdot \frac{v^2}{2}$. The potential energy is $2\pi rdrp$. Hence the total energy is equal to $\pi r\rho v^3 dr + 2\pi rvpdr$. The total energy of the fluid flowing across the section per second is therefore

$$\pi\rho\int_0^R v^3 r dr + 2\pi\int_0^R pvrdr.$$

Also the total volume flowing per second is $2\pi\int_0^R vrdr$, so that the energy per unit volume, or the mean total head, is equal to

$$\tfrac{1}{2}\rho\frac{\int_0^R v^3 rdr}{\int_0^R vrdr} + \frac{\int_0^R pvrdr}{\int_0^R vrdr}.$$

In order, therefore, to obtain the mean total head at a section the values of the above integrals must be determined by taking sufficient measurements of v and p across the section. Thus, in order to determine, for example, $\int_0^R pvrdr$, p and v must be measured at a number of values of r; a curve of the product pvr is then plotted on an r base, and its area gives the value of the integral. The units for the various quantities must be consistent: thus if v is in feet per second, p must be in pounds per square foot ($= 5{\cdot}2 \times$ inches of water), r in feet, and ρ in $\frac{\text{pounds per cubic foot}}{32{\cdot}2}$. The resulting total head will be in pounds per square foot. The total heads at each of the two sections forming the ends of the length of piping whose resistance is required must be obtained in this way, and their difference will be the resistance.

Usually it will be found that, although the pipe diameters at the two sections are different, the sections themselves nevertheless form parts of parallel-walled pipes, so that the flow is axial and p may be taken as constant across the section. The integral $\int_0^R pvrdr$ is then equivalent to $p\int_0^R vrdr$, so that the expression for the mean total head at a section reduces to

$$\tfrac{1}{2}\rho\frac{\int_0^R v^3 rdr}{\int_0^R vrdr} + p. \quad . \quad . \quad . \quad (11)$$

It may be noted that if v is constant across the section it may be taken outside the integrals in which it occurs and the expression reduces to its familiar form of $\frac{1}{2}\rho v^2 + p$.

Now in fan testing and similar work, resistance is a quantity which has frequently to be determined, in addition to the volume of air flowing per second. The latter is deduced by measuring the mean velocity v_m across the section by one of the methods described in subsequent chapters. It is then common practice to say that the mean total head at the section, for the purpose of computing resistance, is equal to $\frac{1}{2}\rho v_m^2 + p$. It will be apparent that this statement is erroneous, and in view of its wide acceptance it is important to examine the magnitude of the possible errors involved.

As a concrete example we may take the case of the smooth parallel pipe for which Stanton measured the velocity distribution as given in Fig. 17. The following table shows the values from which this curve was obtained; here v is the velocity at radius r, v_a is the velocity at the axis and R is the internal radius of the pipe. The integrals occurring in (11) can now

TABLE I.

$\frac{r}{R}$	$\frac{v}{v_a}$	$\frac{r}{R}$	$\frac{v}{v_a}$
0	1·000	0·799	0·789
0·183	0·987	0·852	0·753
0·284	0·967	0·905	0·711
0·389	0·944	0·925	0·688
0·491	0·915	0·954	0·645
0·596	0·883	0·978	0·596
0·698	0·838	0·990	0·388

be evaluated graphically thus:—

For $\int_0^R v^3 r dr$ we may substitute its equivalent

$$v_a^3 R^2 \int_0^R \left(\frac{v}{v_a}\right)^3 \frac{r}{R} \frac{dr}{R},$$

similarly $\int_0^R v r dr$ may be replaced by

$$v_a R^2 \int_0^R \frac{v}{v_a} \frac{r}{R} \frac{dr}{R}.$$

If we now plot on a base of $\frac{r}{R}$ the values of $\left(\frac{v}{v_a}\right)^3 \frac{r}{R}$ and $\frac{v}{v_a} \cdot \frac{r}{R}$ obtained from the above table, we shall derive two curves whose areas are respectively the two integrals required. Thus we shall find that

$$v_a{}^3 R^2 \int_0^R \left(\frac{v}{v_a}\right)^3 \frac{r}{R} \frac{dr}{R} = 0{\cdot}291 v_a{}^3 R^2, \quad . \quad (12a)$$

and

$$v_a R^2 \int_0^R \frac{v}{v_a} \frac{r}{R} \frac{dr}{R} = 0{\cdot}405 v_a R^2, \quad . \quad . \quad (12b)$$

so that the true mean total head, from (11), becomes

$$\tfrac{1}{2}\rho \times 0{\cdot}718 v_a{}^2 + p.$$

Let us compare this with the mean total head erroneously, but frequently, stated to be $\frac{1}{2}\rho v_m{}^2 + p$. In this case

$$v_m = \frac{2\pi \int_0^R v r dr}{\pi R^2} = \frac{2 v_a R^2 \int_0^R \frac{v}{v_a} \frac{r}{R} \frac{dr}{R}}{R^2}$$

$$= 0{\cdot}81 v_a \text{ (from (12}b\text{))}.$$

Hence

$$v_m{}^2 = 0{\cdot}656 v_a{}^2,$$

and the mean total head calculated in this way is

$$\tfrac{1}{2}\rho \times 0{\cdot}656 v_a{}^2 + p.$$

The true mean total head therefore exceeds that calculated by the usual method by $0{\cdot}062 \times \frac{1}{2}\rho v_a{}^2$, i.e. by $0{\cdot}095 \times \frac{1}{2}\rho v_m{}^2$. Now the head corresponding to the mean velocity v_m is, of course, $\frac{1}{2}\rho v_m{}^2$, so that we may say that the error incurred in estimating the mean total head by this incorrect method may be as much as $9\frac{1}{2}$ per cent. of the head corresponding to the mean velocity. The smaller the velocity at a section in relation to the static pressure, the less will be the error on total head. If we take the case, which is of quite common practical occurrence, in which the velocity head (mean velocity) is about equal to the mean static pressure at a section, we see that the mean total head deduced by the usual method may be about 5 per cent. too low—an error of by no means negligible magnitude.

Methods of measuring the true mean total head at any section in practice are described in Chapter V.

Measurements
Industrial & Scientific
An Instruction Book for Engineers

DR. WALTER BLOCK
Eichungsdirektor der Provinz Ostpreussen

CHAPTER III. MEASURING SYSTEM AND GENERAL PHYSICAL CONSTANTS

1. Fundamentals of the Physical Measuring System

The foundation of the physical and technical measuring technique rests on the general physical measuring system, which moreover is also fundamental for the science of chemistry and, with certain modifications, for industry. This basic system of physical measurement will be described in brief. Some of what follows has been mentioned previously but it will be reviewed once more; and in particular there will be given the most exact numerical values known for various quantities.

It is well known that there exist, in the fields of science and technology, a great number of different quantities which must be determined experimentally and evaluated numerically. It is known, too, that all these quantities have certain relations to one another, and that few quantities can be classified as fundamental units. The vast number of different quantities, the values of which are of importance numerically, must be reduced to a conveniently small number of fundamental units, the "set" of which can serve as the basis of a physical measuring system. This question has already been discussed at length in the Introduction, and it was pointed out that the fundamental measuring system of today is derived from three units, a unit of length, a unit of mass, and a unit of time. These are by no means the only three units to which all measurement units can be reduced. Industry, for instance, uses a similar system which, like that of science, is based on the units of length and of time; but, for its third fundamental unit, industry does not use the unit of mass but the unit of weight. Weight and force are in reality identical quantities, for we measure every force only by comparing it with the force which the earth exerts on a body, i. e., the force of gravity. For that reason the weight of a body is equal to the product mg, where m is the mass of a body and g the acceleration due to gravity. This at the same time gives the relation between the so-called physical and the so-called industrial measuring systems.

It is now proper to fix the relation between these fundamental units and the others which can be called derived units, which gives the advantage that a definition of further units can be avoided. Of course, this does not preclude that new units, to be designated as units of second order, may be created for practical use to facilitate operations. Naturally, it is necessary to compare these derived units over certain intervals with the fundamental units, to check their invariability. Examples of such derived units occur in electricity; they are the fundamental electric units for voltage, current, and resistance, generally called volt, ampere and ohm, and a number of others.

It is quite obvious that when starting from a unit of length, a unit of area can be derived directly from it, and be represented by a square with

the unit of length as side. Exactly the same holds true for the unit of volume in its representation by a cube with the unit of length as side. It follows obviously that for these two units no derived units are necessary in practice. Nevertheless such derived units will be introduced in certain cases; as has been done for such a unit of volume as the liter, which in fact, has been derived from the unit of mass.

Furthermore, no new unit will have to be determined for velocity but the unit of velocity expresses that a point moves, in the unit of time, a distance equal to the unit of length. Quite correspondingly, the unit of acceleration is that for which the velocity changes in the unit of time by the unit of velocity. A point having at a certain instant a velocity of 5 meters per second, and after 3 seconds 11 meters per second, has undergone an increase of velocity of 6 meters in 3 seconds, that is, an acceleration of 2 meters per second.

In the following, a short review may be given of how the single units can be derived from one another, and how they are determined numerically.

1. The unit of length, as is known, is represented by the meter and its embodiment by the International Prototype in Paris. For all other details one may be referred to the Introduction.

2. The unit of mass is represented by the kilogram and its embodiment by the International Kilogram-Prototype in Paris. Again one may be referred to the Introduction.

3. The unit of time needs no fixation by any mechanical device as it is given by nature itself in its periodical phenomena. Our time-measuring standards, clocks, must be designated as measuring expedients only as they can be kept permanently directly under observation. As explained above, there is a difference of 235.9 seconds between the mean solar day and the mean sidereal day, the sidereal day being shorter by that amount.

Passing over now to the first of the more complex units, the unit of force, the following may be said: It has been mentioned above that the unit of force is determined in relation to the gravity of the earth, but it is also known that because of several reasons gravity does not act uniformly over the whole surface of the earth. In the first place the earth is not a perfect sphere and various points on its surface are, therefore, variously distant from its geometrical center. In the second place, the centrifugal force at various latitudes naturally varies by reason of varying distance from the axis of rotation. For this reason, a so-called standard value of gravity has to be fixed or, what amounts to the same thing, a point or a geographical latitude where gravity possesses a certain average value. Since many decades a standard value has been adopted for it, which the International Bureau of Weights and Measures has especially determined and fixed at 980.665 cm/sec.^{2} This value is accepted as the average acceleration of gravity on the surface of the earth, and corresponds to the value at an average geographical latitude of 45°. This value is, however, not quite true. It should be, very likely, 980.62. This difference is of no consequence whatever, as for all exact measurements where this value is of importance, one always calculates with the international constant. That means, therefore, that at any point on the earth's surface corresponding to the mean datum of the geoid, a body falling free in space passes through a distance of $\frac{1}{2} \cdot 980.665$ cm in the first second.

On this value of g depend a few quite extraordinarily important units, namely the measuring units for energy and power, the so-called meter-

kilogram and the horse-power, abbreviated to mkg or kgm, and to metric HP, respectively. The meter-kilogram is that energy exerted if a mass of 1 kg is lifted 1 m high against normal gravity. Correspondingly the metric horse-power is that power which exerts 75 meter-kilograms in one second. In pure physics other units are applied, namely the dyne for power, and the erg for energy. A dyne, the unit of force, is therefore that force which imparts to the unit mass the unit velocity in the unit time. Further, it may be pointed out that in physics, the meter and the kilogram are not taken as fundamental units for all measuring systems, because they have proved to be too large, but the hundreth part of the meter, the centimeter, and the thousandth part of the kilogram, the gram. Consequently, a dyne is that force which imparts to one gram in one second the velocity one, whereby, the velocity is naturally determined according to the above definition. That means that one gram-weight, i. e., the pressure which the mass of one gram exerts on its support under the influence of normal gravity, is 980.665 dynes, whence it follows that one dyne is equal to 0.00101976 gram-weight under normal gravity.

Consequently, that energy is designated as unit of energy, one erg, which the unit force performs if its point of attack moves itself in its direction for a distance equal to unit length. From this it follows corresponding to what has been said before, that one erg is equal 0.00101976 cm gram-weight.

From the foregoing it follows further that one mkg = $1000 \cdot 980.6 \cdot 100 = 980.6 \cdot 10^5$ ergs, and one horse-power = 75 mkg = $75 \cdot 980.6 \cdot 10^5$ ergs = $735.5 \cdot 10^7$ ergs.

The physically and technically important unit of *pressure* can, in general, be determined by the assumption of a force acting on a unit surface, that is one square centimeter. Therefore, the unit of pressure is physically determined by the force of one dyne acting on one square centimeter. This unit is designated as one bar. In practice another unit is generally used, namely, the height of a column of mercury in relation with the barometric measurement of air-pressure, and this is generally based on the pressure of a column of mercury of 76 cm height of a section of 1 square centimeter. This pressure is called standard atmospheric pressure or one atmosphere, whereby it is assumed that the mercury is at 0°C and at a place of normal gravity. If the observer is at another place in which there is a different gravity, then the observed pressure multiplied by the local gravity and divided by the normal gravity, is the corrected pressure. For further details on this subject the chapter on pressure measurements may be referred to.

2. The Absolute System of Measurements

In the foregoing, a few details about the fundamental measuring system of physics have been mentioned. Here, only that will be stated briefly which today is considered the generally comprehensive measuring system of natural science and industry.

As already explained, all measuring quantities can be related to the fundamental units for which length, mass, and time have been chosen quite generally. A certain disagreement exists between science and industry. While science considers mass as one of the fundamental units, industry does not, but selects, in its place, force as a fundamental unit.

We must consider that industry does not deal with masses proper. Only masses under the influence of gravity or any other force are of interest, i. e., weights or, better expressed, forces. In this way a regrettable but apparently hardly avoidable disagreement arises which often gives rise to errors, as no one has so far succeeded in obtaining uniformity. Practically the case is such that a body of mass m has the weight mg where g stands for the acceleration of gravity. A mass of 1 g has therefore a weight of 981 weight units.

Unfortunately, there is no ideal measuring system not open to any objection, and even if theoretically the possibility of creating one existed, its introduction would inevitably be opposed by strong practical reasons, by habit and by the many changes in tables, etc.[1] Today conditions are practically as they are described in the following. Following the precedent of Gauss, one today uses as the three fundamental units one unit of length, one of mass, and one of time (l, m, t). The measuring system formed by these units is called, according to his suggestion, the absolute measuring system, which expression distinguishes it from the older relative measuring system, for there can be no question of a really absolute system. Physics has adopted as fundamental units the centimeter (cm), the gram (g), and the second(s). Accordingly this system is also called the CGS System. It has become customary to characterize measuring data in this system by square parentheses, as later often used.

Any quantity of any kind can be derived, as explained above from these three fundamental units. It is therefore a function of l, m, and t, or mathematically: $x = f(l, m, t)$. Practically, as will readily be seen, the case is such that the function can always be represented in the following manner: $x = C \cdot l^{\alpha} \cdot m^{\beta} \cdot t^{\gamma}$, i. e., as a product of the three fundamental units, each raised to a certain power. The exponent of the individual fundamental units is called the dimension of the unit, and the formula for the respective measuring quantity, with indication of that function, is called its dimension formula.

The dimension formula of a quantity depends mainly on which natural law is used for the definition of the quantity. So it is usual to give the electrical units two different dimension formulas depending on whether one starts from Coulomb's law which is based on the electrostatic effects of two electric quantities on each other, or from the electro-dynamic fundamental law which determines the electro-dynamic action of two electric circuits on each other. In this way, two definitions of the electrical measuring units in themselves equivalent but not homogeneous are obtained.

In the following, only the most important measuring units may be tabulated:

Area: Unit is the area of the square with the unit of length as side. Dimension $[l^2]$.

Space: Unit is the cube with the unit of length as side. Dimension $[l^3]$.

Angle: Unit is the angle the arc of which is equal to the radius.

$$\text{Dimension} \left[\frac{l}{l}\right] = [l^0].$$

Velocity: A point has the velocity one if it moves a distance equal to the unit of length in the unit of time. Dimension $[lt^{-1}]$.

Acceleration: Unit is that acceleration at which the velocity is increased by one in the unit of time.

$$\text{Dimension} \left[\frac{l \cdot t^{-1}}{t}\right] = [l \cdot t^{-2}].$$

Acceleration of gravity 980.6 cm sec^{-2}.

[1] Compare Wallot, Dimensionen, Einheiten, Masssysteme in Handbuch der Physik, Vol. 11, page 1, 1926.

Density: Unit is that density of a body the unit of mass of which occupies the volume one. Dimension $[l^{-3}\, m]$.

Density of water at 4° C $0.999973\ cm^{-3}\ g$.

Force: Unit is the force which imparts to the unit of mass the unit of velocity in the unit of time. Dimension $[l\ m\ t^{-2}]$.

$$1\ cm\ g\ sec^{-2} = 1\ dyne$$
$$1\ g\text{-weight} = 980.6\ dynes$$
$$1\ dyne = 1.02\ mg\text{-weight}$$

Pressure: Unit is the pressure with which the unit of force acts on the unit of area.

$$\text{Dimension } \left[\frac{l\ m\ t^{-2}}{l^2}\right] = [l^{-1}\ m\ t^{-2}].$$

$1\ dyne/cm^2 = 1$ bar $= 0.987 \cdot 10^{-6}$ atmospheres.

Work, Energy, heat-quantity (calorie): Force one performs work one if its point of attack moves in its direction the distance of unit of length.

$$\text{Dimension } [l \cdot l\ m\ t^{-2}] = [l^2\ m\ t^{-2}].$$

$1\ [cm^2 g\ sec^{-2}] = 1\ erg = 1 \cdot 10^{-7}$ watt-seconds or Joule $= 2.389\ 10^{-8}$ cal.

1 meter-kilogram $= 98.06 \cdot 10^6$ ergs.

426.9 g-weight $\cdot$ meter $= 1$ cal.

Power: The Unit of power exists if in the unit of time the unit of power is performed.

$$\text{Dimension } \left[\frac{l^2\ m\ t^{-2}}{t}\right] = [l^2\ m\ t^{-3}].$$

$1\ [cm^2 g\ sec^{-3}] = 1\ erg/sec = 10^{-7}$ watts $= 1.36 \cdot 10^{-10}$ metric horse-power.

$$1 \text{ metric horse-power} = 75\ \frac{\text{kg-weight} \cdot \text{m}}{\text{sec}} = 735 \cdot 10^7 \text{ CGS-units.}$$

Electric quantity (electro-static): Unit is that quantity which repels in vacuum the equal amount with the force one.

It is therefore $k = \dfrac{e\ e}{l^2}$ dyne according to Coulomb's law. Therefore $e = l\sqrt{k}$, k has the dimension $[l\ m\ t^{-2}]$. Therefore the Dimension $[l^{3/2}\ m^{1/2}\ t^{-1}]$.

Potential (Electro-static): The unit of potential has the electric quantity one distributed uniformly on a sphere of radius one. Dimension $[l^{1/2}\ m^{1/2}\ t^{-1}]$.

$$1\ [cm^{1/2}\ g^{1/2}\ sec^{-1}] = 300\ volt.$$

Capacity (electro-static): A conductor possesses unit of capacity if it is charged by quantity one to potential one. Dimension $[l]$.

$$1\ [cm] = 10^{-6}\ micro\text{-}farads.$$

Current (electro-static): A current has unity at which the electric quantity one flows in the unit of time through the section of the conductor.

$$\text{Dimension } [l^{3/2}\ m^{1/2}\ t^{-2}].$$
$$1\ [cm^{3/2}\ g^{1/2}\ sec^{-2}] = 3.33 \cdot 10^{-10}\ Amp.$$

Resistance (electro-static): A conductor has the unit resistance if the difference of potential one between its ends produces the current one. Dimension $[l^{-1}\ t]$.

$$1\ \left[\frac{\text{sec}}{\text{cm}}\right] = 9 \cdot 10^{11}\ ohms.$$

Current (electro-dynamic): Unit is the current in a conductor whose unit of length exerts the force one on an equal length.

$$\text{Dimension } [l^{1/2}\ m^{1/2}\ t^{-1}].$$
$$0.1\ [cm^{1/2}\ m^{1/2}\ t^{-1}] \text{ has been fixed as one ampere.}$$
$$1 \text{ ampere} = 3 \cdot 10^9 \text{ electro-static GCS.}$$

Electric quantity (electric-dynamic): Unit is that quantity which moves the unit of current through the section of the conductor in the unit of time.

$$\text{Dimension } [l^{1/2}\ m^{1/2}].$$
$$0.1\ [cm^{1/2}\ g^{1/2}] = 1 \text{ ampere-second, or } 1 \text{ Coulomb.}$$

Electro-motive force, or *voltage* (electro-dynamic): Unit is that electro-motive force which, when producing current one, performs the unit of power in the unit of time. It is therefore voltage $\times$ current $\times$ time $=$ work, as is known: that is $e \cdot [l^{1/2}\ m^{1/2}\ t^{-1}] \cdot [t] = [l^2\ m\ t^{-2}]$

$$e = [l^{1/2}\ m^{1/2}\ t^{-2}].$$
$$\text{Dimension } [l^{1/2}\ m^{1/2}\ t^{-2}].$$
$$10^8\ [cm^{3/2}\ g^{1/2}\ sec^{-2}] = 1\ volt.$$

Resistance (electro-dynamic): That conductor has unit of resistance in which the voltage difference one produces current one.

$$\text{Dimension } [l\ t^{-1}].$$
$$10^9\ [cm\ sec^{-1}] = 1\ Ohm.$$

Electric power (electro-dynamic): The unit is produced by a current one in a resistance

one, or by the current one which produces voltage one.

Dimension $[l^2\ m\ t^{-3}]$.

$$10^7\ [\text{cm}^2\ \text{g}\ \text{sec}^{-3}] = 1\ \text{Watt} = 10^7\ \text{erg/sec}.$$

Electric energy (electro-dynamic): Unit is the energy of current one in the resistance one. Dimension $[l^2\ m\ t^{-2}]$.

$$10^7\ [\text{cm}^2\ \text{g}\ \text{sec}^{-2}] = 1\ \text{Joule} = 10^7\ \text{ergs}.$$

It must be noted that the ratio of electro-static to electro-magnetic units is always represented by a power of the velocity of light, a fact which is mentioned here without further proof.

3. The Most Important General Physical Constants

In connection with the foregoing a few other units may be mentioned here which can be designated as general physical constants, and which, for their practical application, need only an international agreement. Among these, the *electro-chemical equivalent of silver* must be called the most important.

It is known that for electric measurements, the fundamental units are the ohm and the ampere, the relationship of which to the fundamental units are far from direct and very difficult to prove. These relations, in fact, are not usable for practical use; hence the need of especially stipulated secondary units. Among these is the electro-chemical equivalent for measurements of current. According to present international agreements the *unit of current* is determined by the application of the silver-voltameter, by stipulating that the practical unit of current (one ampere) must deposit in one second, and under prescribed test conditions, a certain amount of silver in the silver-voltameter. By a series of experimental investigations this quantity has been fixed; but it is not quite sufficient for practical use and actually obtainable conditions of accuracy, and therefore the unit of current has been defined in the several countries as that which in one second deposits the round value of 1.11800 milligrams of silver in the silver-voltameter.

In similar manner, *the atomic weight of oxygen* has been determined by international agreement, namely the known value of 16.000.

In connection with these constants, there may be discussed in greater detail a number of others which have been determined by dint of thorough experimental investigations. First, the *specific gravity of water* in the state of its highest density. As mentioned in the introduction, water of highest density has been chosen as the standard substance for the determination of the unit of mass a decision which can in no wise be objected to, even from the modern point of view. It was stated that a cubic decimeter of pure water at that state should represent the unit of mass but that this ideal relation had not been satisfactorily realized. If the international kilogram-prototype is checked back according to that definition, in order to determine the space which a kilogram of pure water actually occupies, a value slightly different than one cubic decimeter is arrived at, which is called the liter. The figures published so far on the relation between the cubic decimeter and the liter have shown (compare INSTRUMENTS, November 1929, page 401) that the liter is equal to 1.000027 cubic decimeter. The reciprocal value of this number (0.999973) thus at the same time gives the real density of water in the state of its greatest density. If, therefore, by specific gravity is meant, as usual, that number which gives the ratio between the mass of a body to the mass of *water* having the same volume, the density of any other body is obtained if its specific weight so found is multiplied by that density of water. This difference

is of on practical importance, because in general for accurate determinations of density the unit cubic decimeter is not used, but the liter unit—which eliminates the difference altogether. Unfortunately, both designations are interchanged in common speech and writing.

In chemistry the knowledge of the number indicating the *volume of a mol* of a gas is of considerable importance. The normal mol-volume, according to the law of Avogadro, is independent of the particular gas. Oxygen is the gas employed for the determination of this number for the reason that its atomic weight is fixed by definition, i. e. the mass contained in one liter under standard conditions of one atmosphere pressure and 0°C temperature. The determination of this number made so far give, according to Henning and Jaeger[1] $1.42896 \cdot 10^{-3}$ for the density of oxygen, from which follows the normal mol-volume of 22.4139 liters.

As with the normal density of water, the *density of mercury* is of considerable importance with regard to its use in the determination of volumes and pressures. From the observations made in this respect it is evident that mercury, is not uniform to such an extent as it is apparently the case with water. From the tests of Scheel and Blankenstein[2] the best value for the density of mercury at 0°C can be assumed to be 13.59546.

For the majority of physical measurements, the so-called *atmosphere* is accepted as the standard unit of pressure, that is the pressure of a column of mercuty 760 mm height under normal gravity at a temperature of 0°C. This so-called physical atmosphere is entirely determined by the conditions stated above. From the known figures, the pressure of one atmosphere is then equal to $1.013253 \cdot 10^6$ dynes per cm^2. The technical atmosphere differs from the physical by about 3%; it is defined by the pressure of 1 kg on the unit of area under the action of normal gravity and is therefore equal to $0.980665 \cdot 10^6$ dynes per cm^2. Closely connected with the atmospheric pressure is the energy value of the liter-atmosphere. That is, the amount of energy which must be expended when any volume of a gas is to be increased by 1 liter against the pressure of a physical atmosphere. It is, therefore, equal to $1.013280 \cdot 10^9$ ergs.

For the conversion of gas constants and gas conditions, a knowledge of the so-called absolute *zero-point of temperature* is required. This knowledge is derived from observations of the volume and pressure coefficients of gases and by extrapolation after correcting the observed figures for the absolute temperature 0 and for the ideal gas (from which, naturally, all gases deviate in their behavior). The results so far known give for this figure the value of −273.2°C.

According to the general laws of gases, a simple relation exists between the pressure, the volume, and the absolute temperature of a gas which is represented by the formula $p \cdot v = R \cdot T$. In this equation the constant R refers to the quantity of gas contained in the volume v. As is known, R has the same value for all gases if the masses of the respective gases are in the ratio of their molecular weights. In general, by gas constant is understood that value of R which corresponds to one mol of the gas. From the above given figures the value of the gas constant is obtained as $0.83132 \cdot 10^8 \frac{\text{erg}}{\text{degree}}$ or $82.045 \frac{\text{cm}^3 \cdot \text{atmospheres}}{\text{degrees}}$. From these figures, the transition to

[1]Henning and Jaeger, Handbuch der Physik, Vol. 11, page 488 and following, Berlin 1926. This work may be especially referred to; it is used here in essence.
[2]Scheel and Blankenstein, Zeitschrift fuer Physik, Vol. 31, page 202, 1925.

other energy units and heat units follows.

Another quantity of importance to chemists, especially for conversion purposes, is the so-called mechanical *heat-equivalent*, i. e. that energy which is necessary to increase the temperature of 1 kg of water by 1°C. The water should initially be at 15°C. This number, too, must be determined entirely experimentally. The best series for this value seems to be that carried out in the Physikalisch-Technische Reichsanstalt by Jaeger and von Steinwehr[1] which gave for its value 4.1842 international units or $4.1863 \cdot 10^7$ ergs.

Throughout the field of electro-mechanics, and for all electrical measurements, the international electric units and the so-called absolute electric units are accepted. These latter are defined by the relations of the electrical measurement quantities to the fundamental units of the absolute system of measurement, a definition which will not be discussed here. They are hardly applicable for practical use, great as is their basic scientific importance.

It thus has been absolutely necessary to develop special practical units for use in scientific and technical laboratories and then to determine by special experiments their relationships to the absolute units. Further, it has been necessary so to choose the magnitude of the units that they were suitable for practical use, which was not directly the case with the absolute units. The international units which have been brought forth after such deliberations are, so to speak, empirical standards which are so defined by law that they approach with the greatest possible accuracy the value of the absolute quantities. According to the German law of July 1, 1898, on the electrical units, two units, the ohm, and the ampere, are legally defined. From these two definitions, the third quantity, the volt, can be derived directly, and in similar manner also the compound units. The law stipulates: the ohm is the unit of electrical resistance, it is represented by the resistance of a mercury column at the temperature of melting ice, the length of which column is 106.3 cm with an absolutely uniform cross-section of one square millimeter, and the mass of which is 14.4521 g, the ampere is the unit of electric current, it is represented by the invariable electric current which, when passing through an aqueous solution of silver nitrate, deposits 0.001118 g. silver in one second.

These definitions have been accepted internationally with insignificant changes. The one important change is the *definition of the ampere* which gives the above figure more exactly as 0.00111800 g. silver.

It must be realized that the unit of the ampere does not represent a tangible unit, but has to be made in every individual case by different investigators under inconvenient conditions.

In practice therefore, not the ampere, but in its stead the *volt* is used as the *basic electrical unit* which can easily be represented (though not realized as "the quantity of exactly one volt" yet an analogous one) by a suitable standard cell. This standard cell is the so-called Weston element whose voltage has been fixed at 1.01830 international volts at 20°C. This value, and this cell, are used in actual practice for all better electrical measurements. This figure is, of course, derived on the basis of the international agreement on the ohm and ampere, so that the Weston cell, as the standard for voltage represents in fact only a secondary unit.

[1] Jaeger and v. Steinwehr, Berliner Berichte 1915, page 424; Annalen der Physik, Vol. 64, page 305, 1921.

A number of investigations regarding the relation between *international* and *absolute ohm* have been published, showing that the international ohm is, with fair accuracy, equal to 1.0005 absolute ohm.

The relation of the *international* to the *absolute ampere* can only be determined with the greatest difficulty, since the test results with different methods have not given identical figures, by reason of the difficulty of the experiment. It can be fairly assumed that the *legal* definition of the ampere agrees very exactly with the *absolute* ampere. The discussions on the relation of the international ampere to the absolute, by the way, have not yet been fully concluded. There exists, therefore, no need for further discussion here.

The *elementary quantum* of electricity, i. e., the charge of an electron, has been mostly calculated by the work of Millikan. Generally, the number of $4.774 \cdot 10^{-10}$ electro-static units is accepted for it.

Loschmidt's number is understood to be the number of molecules in one mol. According to test results so far obtained this number is $6.061 \cdot 10^{23}$, which gives the value of $1.650 \cdot 10^{-24}$ g. for the mass of a hypothetical atom of atomic weight 1 or for the 16th part of the mass of an oxygen atom.

The *velocity of light*, an extremely important number especially for the electrical measurement quantities, is determined by methods which are fundamentally entirely different, such as the purely optical, by actual observation of velocities, or purely electrical methods in connection with the theory of Maxwell as to the relations of electric quantities among themselves, which have been determined (in the absolute system of measurements) in their electro-static and electro-dynamic values. According to Maxwell's theory, these two values must be in the ratio of velocity of light if the same electric unit is measured once with the one, then with the other system. Observations give an average value for the velocity of light of 299,868 kilometers per second, which holds good for the propagation of light in vacuo. This value is obtained from the purely optical measurements. From purely electrical measurements, a value differing slightly is obtained, it corresponds to present limit of accuracy of measurement if, from both methods, an average value of 299,850 kilometers per sec. is accepted.

On February 1 the Moeller Instrument Co., Inc., 261 Sumpter St., Brooklyn, N. Y., succeeded the A. E. Moeller Co. The active ownership and management will remain the same as for many years past under the following personnel: Charles E. Moeller, president and general manager; Max E. Moeller, vice president and head of research department; Curt F. Moeller, treasurer and factory manager; Paul G. Moeller, secretary and sales department; Otto J. Moeller, assistant treasurer and glass production department; and Walter G. Moeller, production department.

"King & Shepherd, 50 Church Street, New York City, have been appointed distributors for the Manhattan district, of the Mason Regulator Company, General Offices and Plant Dorchester Center, Boston, Mass. The line consists of all the newest developments in pressure control apparatus. Both Mr. King and Mr. Shepherd are technical men and salesmen, are able to offer expert engineering advice in the solution of the pressure control problems."

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by Instruments Book Shelf, Instruments Publishing Company, Pittsburgh, Pa.

Introduction to Physical Optics. *By John Kellock Robertson.* D. Van Nostrand Co., New York, 1929. Cloth, 6 x 9 inches. Price $4.00.

The author has comprehensively covered the field of physical optics with at least one excursion into a field not usually included in the subject. His reason for including the work on lenses found in the latter part of Chapter III and all of Chapter IV is evidently his method of attack through the medium of physical optics. This method proves awkward, however, and he quickly abandons it. All of Chapter IV is pure elementary Geometrical Optics, as is also Chapter V, except for a few paragraphs on Physiological Optics.

The exposition of wave motion in Chapter II is a clear and concise handling of a subject that is not always presented in such an understandable manner. Huygens principle is well set forth in the fore part of Chapter III.

Chapter VI begins on a note of pure physical optics by a discussion of dispersion through a prism. The spectrometer, spectrograph, and spectroscope are described and their theory discussed mathematically. However, the latter part of this chapter digresses again to Geometrical Optics with a discussion of achromatic lens combinations.

Chapter VII introduces the readers to the mysteries of spectroscopy, with some mention of the Doppler, Zeeman and Stark effects.

Chapters VIII and IX are devoted to a thorough exposition of interference. Chapters X and XI cover diffraction, Fresnel and Fraunhofer respectively. These four chapters cover the elementary classical theory in much the usual way, but the reader is impressed by the clarity of presentation. The author has used strong pictorialism throughout the work. His method of presentation makes the work very readable. This characteristic is particularly valuable when polarization phenomena are taken up in Chapters XII and XIII. Instead of proving the most difficult part of Physical Optics to understand, these two chapters are really good reading.

The last eight chapters take up the more advanced and recent developments of physical optics. There is a complete introduction to the electromagnetic theory of light. Considerable space is devoted to the emission of light from the ultimate source, taking the reader through the quantum theory from Plank's radiation formula up to the wave mechanics of De Broglie and Schrodinger. The last chapter describes the experimental work leading up to the theory of relativity.—Dr. Harry G. Ott.

Calorimetry Issue of INSTRUMENTS. Instruments Publishing Co., Pittsburgh, Pa., Feb. 1930. Paper, 6 x 9 inches, 128 pages. Price 50 cents.

The February issue of "Instruments" is devoted almost entirely to Calorimetry in all its branches. When one issue of a magazine contains articles by such eminent authorities as Professor S. W. Parr, W. E. Stackhouse, Dr. Walter Block, and describes in detail calorimeters from the industrial steam calorimeter down to a micro calorimeter, such an issue of a magazine can almost be called a book on calorimetry. There are some sixty odd pages of this number devoted exclusively to the design, construction and use of calorimeters. Coal Calorimeters, Gas, Steam, Recording Gas, Oxygen Bomb, Peroxide Bomb, Adibatic, Micro, Hand Calorimeters, Bomb Calorimeters and B. T. U. Indicators are all described quite fully from both scientific and industrial viewpoints. The descriptions of the individual instruments will give the reader a very broad, intimate knowledge of the design, construction and use of the various calorimeters described so that he will be in a position to select from all the calorimeters available on the market that one most suited to his particular needs. This one number of the magazine is a virtual handbook on calorimetry. It is hoped that future numbers will cover subjects like Physical Testing of Metals, Thermal and Electrical Conductivity, Magnetism, and similar subjects in the same thorough manner.—A. Schroder.

Air Navigation and Meteorology. *Captain Richard Duncan.* Goodheart-Willcox Co., Chicago, 1929. Cloth flexible, 5½ x 8, 225 pages. Price $3.00.

The introduction states that this book is intended "to serve as a text-book for the student, and as a reference book for the experienced pilot." It can not be recommended for either purpose. The book is an incomplete, often inaccurate, incoherent discourse interspersed with "excerpts" from government publications, aviation magazines and advertising literature. Practically all of the chapter on instruments, for example, consists of verbatim transcriptions from the descriptive pamphlets of a single manufacturer. The original illustrations are misleading and inaccurate in many cases.—K. Hilding Beij.

Markscheidekunde. *P. Wilski. Julius Springer*, Berlin, 1929. 250 pages. 26 R. M.

Dr. Wilski is professor of surveying in the Technische Hochschule Aachen, and this book is the outgrowth of an earlier one on mine surveying, so that there is frequent reference to mining conditions and the solution of the problems which are given toward the end of the book seem to have been selected with the needs of the miner in mind. The book concludes with a series of plates showing surveying instruments.

NEW INSTRUMENTS

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Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

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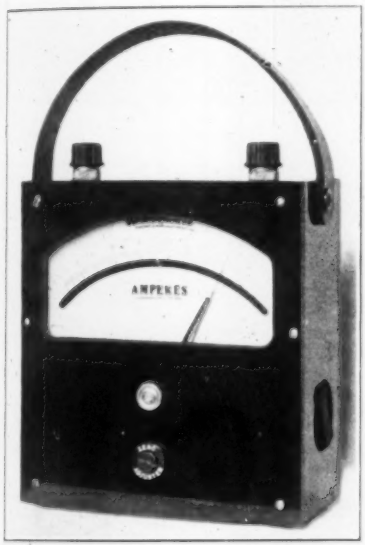
(Westinghouse Electric & Manufacturing Company)

The Type PY-5 Motor Starting Ammeter is a new compact instrument which enables an accurate measurement of the instantaneous starting current of a.c. and d.c. motors, a measurement accomplished heretofore only with an oscillograph.

This instrument can be used also as an ordinary ammeter. Such measurements as starting current, locked-rotor current, and running current are made without disconnecting the instrument from the line. The instrument has a double range, and change over from one range to the other is accomplished simply by turning a switch on the side of the case.



This instrument, which is direct reading, is suitable for general testing and laboratory work, where especially high and positive accuracy is required and particularly on alternating current, and, because of the permanence of calibration, for use as a transfer standard for calibrating and checking other instruments.

To measure the motor starting current, the instrument is connected in the circuit like any other ammeter, but the reading is taken by the "set and try" method. The pointer is set to approximately the right position by means of the manually-operated stop, and the power is turned on. If the setting proves high or low, the pointer is reset and a second trial made. A few trials may be necessary before final adjustment is reached, after which the needle will quiver just a little when the current is turned on, indicating that the maximum starting current is being measured. This indicator will be within 3% of an oscillograph's exact record. After the reading is taken, the stop can be returned to zero.

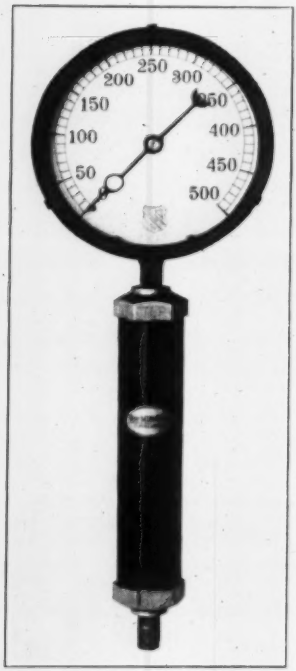
The ammeter has a moving iron vane mechanism with an air chamber for damping the oscillations of the pointer. The moving element is quite light and very responsive to slight quick changes in current.

The case is made of micarta with a walnut finish and nickel trimmings, and is provided with a flexible leather handle.

A Shock Absorber for Pressure Gages

(Meriam Company)

THE illustration shows a device designed to avoid the difficulty of getting correct pressure or vacuum gage readings on pipe-lines containing liquids, steam etc. whose flow is pulsating.



This flow condition is often met where reciprocating pumps must be installed in lines where it is impracticable or too costly to install air-receivers. The same condition may also be met with in pumping service where considerable solid matter is carried in suspension, as in sand pumps, digester tank pumps, etc; because for such impeller blades must necessarily be comparatively few and widely spaced.

The construction of this shock-absorber is simple and has no moving parts which can wear or get out of adjustment, and the device has operated successively even under such severe conditions as exist on a pipe line fed by a duplex reciprocating pump operating at 1200 lbs. in^2 without any air-receiver.

The device consists of a steel air-tight chamber in which is a long spiral coil of tubing having a small bore. The remainder of the interior of the chamber is hollow and acts as a small air receiver for the gage mounted at the top. This spiral coil is connected to the pipe line at one end opening directly into the chamber. The pulsations in the pipe line are therefore largely dissipated by friction in passing through the long narrow bore of the tube. The small remaining amount of pulsation is absorbed by the cushioning effect of the air in the chamber itself. The gage is connected to a vertical tube which has its opening inside the chamber close to the bottom. Pulsations and shocks therefore are eliminated, and thus the gage reads only the average pressure instead of registering the usual "jumpy" effect which is so hard to determine accurately. The length of the coiled feed pipe is of course proportioned to suit the conditions of the pipe-line on which it is used.

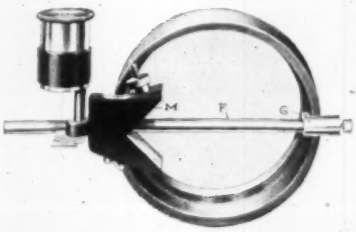
Leeds & Northrup Company, Philadelphia, Pa. announces its Cleveland office is now located in larger quarters at 1941 Union Trust Building, Cleveland, Ohio.

Thread Profile Gage

(Bausch & Lomb Optical Company)

THOSE accustomed to cutting screw threads on a lathe or similar machine tool are well aware of the importance of having the tool accurately ground to the required angle and firmly set in the tool post in proper relation to the work.

By ordinary means it takes time, patience and skill to make this setting, yet with the aid of the external and internal profile gage the tool setting can be checked as well as the angle of the tool.



The body of the thread profile gage has a vee which is placed against the circumference of the work and clamped in place by a screw. The top of the thread gage is placed in the same horizontal plane as the lathe center by rotating the work with the instrument attached to it, until the air bubble is central in the level vial.

Then with the thread tool loose in the tool post the tool is brought forward and the point is brought into contact with the vee in the gage. The top surface of the tool should be flush with the surface of the gage. If the tool is properly ground, it will be in contact with the side of the gage, but if improperly ground the error may be readily detected, since light will pass through between the edge of the gage and the tool.

The accuracy of the setting and of the tool point can be readily observed through the magnifier lens which is mounted directly over the gage, and magnifies 4×. The magnifier is adjustable to suit the vision of the observer. The level vial is sensitive to one minute of arc. After setting the tool, the instrument is removed before the lathe is started.

The lower illustration shows the application of this instrument to work of comparatively large diameters. The instrument is fastened to the work by means of a chain attached to an extension spring at the bottom of the instrument and hooked over the stud at the top. The spring holds the chain tight and prevents the instrument from slipping on the work. After the instrument has been attached to the top of the work to be threaded, it is placed in a horizontal plane by rotating the work and observing the level vial, and the tool is set as in the previous example.

Tools for cutting internal threads can be set by gaging the cutting point of the tool in the gage vee opposite the vee used in setting for external threads. Magnifier is then moved on its brackets to bring it directly upon this second thread gage vee.

If internal threads are to be cut in parts having no finished outer surface that permits the attachment of the instrument in the manner described, the instrument may be fastened as shown to the finished internal surface on which the threads are to be cut. Rod f is inserted through the center of the body, m, with the instrument key to the right. On the body of the instrument hardened and ground surfaces are located equidistant above and below the rod to contact the finished surface of the work in two points.

The first contact is made opposite these points by means of a small half sphere attached to the sleeve, g.

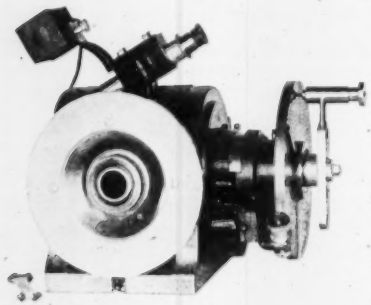
After contact has been made with the work at the three points, the clamp on the bottom of the instrument body is tightened to the right of the adjustment to the rod f, and thus prevents it from slipping over the work. A small screw on sleeve g is then turned to tighten the half sphere firmly against the work.

After the instrument has been attached to the work in this manner the procedure of setting the thread tool is exactly the same as in the cases already mentioned.

Optical Indexing Device

(Bausch & Lomb Optical Company)

THE Optical Indexing Device checks the accuracy of each position of the dividing head before the milling operation. It shows any mechanical inaccuracies and permits the operator to quickly make the necessary correction, saving uncertainty, spoiled work and lost time. This device offers a sure method of getting precise work, accurate to within a fraction of a minute of arc.



The indexing device consists of a microscope, a large graduated disc, an eccentric disc for fine adjustment (or worm screw), and a lamp for illuminating the graduations on the disc. The microscope is provided with a rectangular prism at the eye end for convenience of the operator. This prism can be swivelled into such a position that the observation can be made from the side, from an inclined position or from the top. The disc has three graduated circles, one being graduated to 720 divisions, a second into 791 divisions and the third into 800 divisions. Special discs having other numbers of graduations can be supplied.

In using a dividing head equipped with this optical device, the work is attached to the dividing head spindle and the head is indexed in the regular manner. If the proper graduation on the master disc does not exactly coincide with the index line in the eyepiece of the microscope, a slight turn of the knurled eccentric disc makes the correction. Then the spindle of the dividing head is locked in the usual way.

In machining metal having hard spots, the cutter will sometimes cut unevenly and cause the dividing head spindle to shift slightly. If an accurate gear or similar part is being produced when this occurs, there may be an appreciable error between the last and the first cut. With this optical device, however, such errors can be obviated by observing each setting before starting the cuts and before indexing for the next cut. Numerous other applications of the optical indexing device, such as boring the bearings of multiple spindle heads, have been advantageously made.

New Position Recorder

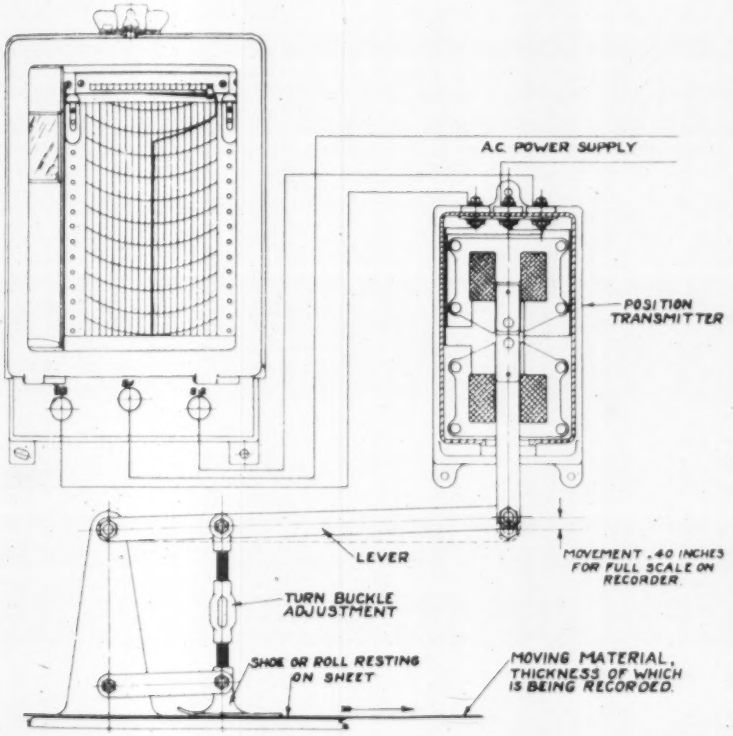
(*Esterline-Angus Company*)

Records of Position. The position or motion of machines or devices is often important when their correct operation controls processes, or ties in with the operation of other equipment.

Such items as: *The position of dampers—the setting of valves—the opening of gates—the motion of rams—the position of governors—the height of liquids in tanks—the head of water in reservoirs—the height of gas holders*—all are easily and accurately recorded with graphic instruments.

Records of Thickness. The thickness of sheet materials is important where uniform thickness either affects the use of the product in subsequent processes, saves in the amount of raw materials used, or controls the quality of the finished product.

The thickness of materials such as: Cardboard of all kinds—wall board—insulating materials—sheet packing—tire fabric—sheet and strip metals—can be continuously recorded. Such a record amounts to continuous inspection of the product, where in some cases manual inspection is either impossible or too expensive.


A.C. POWER SUPPLY
POSITION TRANSMITTER
LEVER
MOVEMENT .40 INCHES FOR FULL SCALE ON RECORDER.
TURN BUCKLE ADJUSTMENT
SHOE OR ROLL RESTING ON SHEET
MOVING MATERIAL, THICKNESS OF WHICH IS BEING RECORDED.

Two distinct types of position or thickness recorders are available: an electrically operated meter for use where the relative positions or thicknesses must be transmitted to a remote point and a mechanically actuated

instrument for installation where the meter may be mounted at or near the measurement.

Electrically Operated Recorder. Where it is necessary to record position or thickness at points remote from the place of measurement, an electrical type of recorder is used. The electrical recorder consists of a standard electrical instrument operated through a three-wire circuit by a transmitting device.

There are two types of transmitters, one operated by a lever extending through the bottom of the case, and the other operated by the rotary motion of a shaft. The operating principle is the same in both cases, except that in the rotary type an arrangement is made to convert the rotary motion to a sliding motion of the plunger. Any movement of the lever or rotary shaft is transmitted electrically to the instrument, and the writing pen follows the movement of the transmitter, accurately and smoothly. Since the curve produced by the meter is directly proportional to the movement of the transmitter, the scale and chart used are evenly divided.

A movement of .40″ by the plunger of the transmitter causes full scale movement of the recorder pen. The rotary type is designed so that a shaft rotation of 180° corresponds to full scale on the meter. The rotation may be either clockwise or counter clockwise.

The system may be operated from either a 110 or a 220 volt 60 cycle circuit, and the reading is independent of ordinary voltage variations of the supply circuit. The circuit requires but three wires, and the meter will operate through a maximum resistance of 50 ohms per wire which represents approximately ten miles of No. 10 wire.

The mechanical system between the point of measurement and the transmitter must necessarily be devised for the particular job in question. Thickness measurements are usually made with a shoe or roller riding on the product and the area of the shoe or roller in contact with the material must be such as to take care of the pressure required to operate the device. In most cases, however, counterbalance springs can be provided to reduce the pressure to the minimum needed.

Mechanically Operated Device. The mechanical motion or thickness recorder has a movement actuated by a lever extending horizontally through the case. This lever is mechanically connected to the recording mechanism so that a movement of 1½″ corresponds to full scale on the instrument. The actuating lever extends through both sides of the case, permitting attachment of the operating mechanism on either side.

The recording instruments used with both the electrical and the mechanical device are furnished in standard switchboard, wall and portable type cases. Standard eight-day marine clocks or synchronous motor driven clocks are available, giving speeds of ¾, 1½, 3, 6 and 12″. per hour and the same per minute. If required, a motor driven chart can also be furnished with speeds of ¾, 1½, and 3″ per second. Indicating meters are available and may be installed in the circuit of the electrical transmitting device when it is necessary to indicate the reading at one point and record it at another. This permits the use of an indicating instrument by the machine operator, and allows the recording instrument to be located at any convenient point.

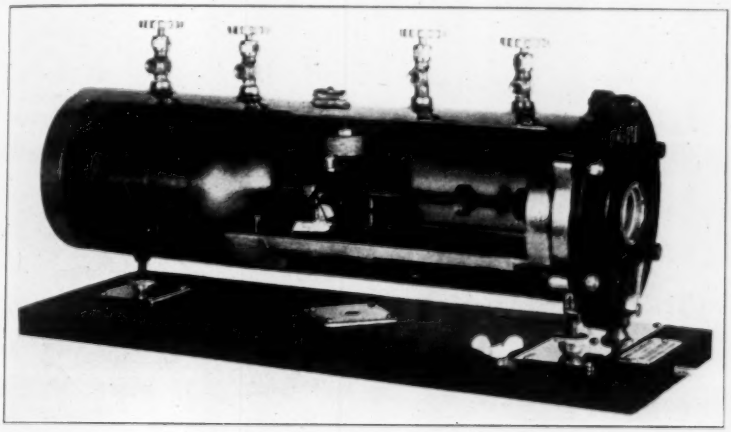
The Improved AC-ME Specific Gravity Gas Balance

(Refinery Supply Company)

The operation of the Specific Gravity Balance is based upon the laws of compressibility and buoyancy. It is described in Technologic Paper No. 89, Bureau of Standards, as follows:

> "According to Boyle's law the density of a gas is proportional to its pressure; and the buoyant force exerted upon a body suspended in a gas is proportional to the density of the gas and therefore to its pressure. Therefore, if the buoyant force exerted upon a body is made the same when suspended successively in two gases, then the densities must be the same at these pressures; or the densities of the two gases at normal pressure are inverse ratio to the pressures when of equal buoyant force."

The Improved Ac-Me Specific Gravity Balance consists of a balance



beam carrying a sealed float on one end and an adjustable counterbalancing weight on the other end. This balance beam is suspended by means of two crossed phosphor bronze strips on each side. The crossed suspension permits the beam to have free movement about the point of oscillation but prevents the lateral motion of the beam. The end of the balance beam is equipped with a millimeter scale which is used in connection with a hair-line indicator to show when the beam is in balance. The container of the balance is provided with an ample number of valve connections to take care of the various hook-ups necessary in making a balance test. The connections on each end are provided with purging rings which aid the thorough purging of the instrument and prevent the deposit of any moisture on the internal mechanism of the balance.

The specific gravity of a gas referred to air as unity may be represented as the ratio of the absolute pressure required for balancing the beam in air to the absolute pressure required for balancing the beam in the gas, ex-

pressed as a formula:

$$\text{Sp. Gr.} = \frac{A}{G}$$

Where A = the manometer pressure plus (algebraically) the barometric pressure, while the beam is balancing in air.

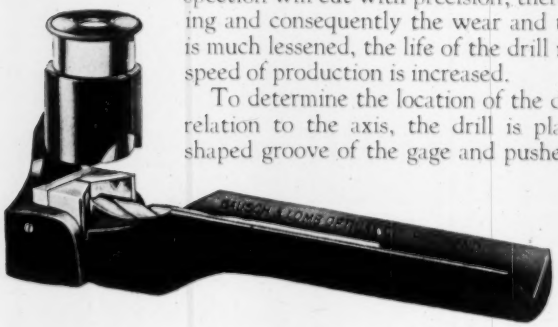
G = the manometer pressure plus (algebraically) the barometric pressure, while the beam is balancing in gas.

The improved Ac-Me Gravity Balance, including the four spring type of suspension recommended by the Bureau of Standards, has been adopted by the Natural Gasoline Association as a tentative standard.

Optical Drill Gage

(Bausch & Lomb Optical Co.)

THIS ruggedly designed drill gage is simple in manipulation and accurately checks drills for the following: (a) to determine the location of the drill point or the apex in relation to the axis of the drill; (b) to see if the cutting lips are both inclined at the same angle relative to the drill axis; and (c) to determine whether the web is central relative to the drill axis.



A drill ground to conform with the above rigid inspection will cut with precision; there will be no chattering and consequently the wear and tear on the machine is much lessened, the life of the drill is prolonged and the speed of production is increased.

To determine the location of the drill point or apex in relation to the axis, the drill is placed in the long V shaped groove of the gage and pushed forward until the lips are in contact with the profile block, which is located directly under the magnifier. The drill is then rotated until the apex is parallel to the line of sight. The magnifier is focused on the drill by sliding the former in or out of its supporting sleeve. If the point of the drill is exactly true with the axis it will be central to the narrow slit formed by the parallel adjacent sides of the slit in the gage block. This slit is .003 inches wide, and serves as a basis for estimating the amount that the drill point is off center.

In checking up the angles of the cutting lips, the drill is held in the V shaped groove in the same manner, with the cutting lips at right angles to the line of sight. When the drill is again brought into contact with the gage block, any difference in the angle of cutting lips will be revealed by lack of contact with the gage surfaces.

When checking the web position, relative to the drill edges, the drill is held in the V groove with the point or apex at right angles to the line of sight. The corners formed by the apex and web then touch the two gage blocks if the web is central. The web is not central if only one point is in contact.

Hot Molding Pyrometer

(Jewell Electrical Instrument Company)

THE science of hot molding of either shellac base materials, or products which polymerize, such as bakelite, durez, condensite, and other resins of this character, is directly dependent upon the heat and pressure applied. The pressure can readily be measured by gages and unit pressure obtained from the mold area, but the temperature at the face of the die has been left largely to chance up to the present time. Steam temperature is indicated with a thermometer. Platen temperatures may be indicated by special devices, but the actual mold temperature has been given but little consideration.

The hot molding pyrometer, Pattern No. 80, has been designed to give rapid and accurate temperature readings of all portions of a mold, be it of the hand-operated or automatic type. It consists of a high-grade D'Arsonval movement in an insulated case, properly shielded magnetically and compensated for variations in room temperature. It is supplied with a scale reading from 50°F. to 400°F. in 5° divisions, the scale being 3½" long.

Extending from the right of the case is a chromium plated flexible metallic hose, carrying the special leads from the thermo-couple tip which is mounted on a swivel joint at the end of a handle of insulating material. The thermo-couple tip is brazed into a tiny copper disc, so that it cannot be damaged in ordinary use, and will last for years.

Accompanying the instrument is a heavy block of brass, containing a steel mercury well, into which the thermometer accompanying the instrument may be inserted.

When it is desired to check the pyrometer, the block is placed on a hot plate, the pyrometer is placed in an aperture on the block and a check may be

had between the thermometer readings and the instrument readings. In this way a continuous accurate control may be kept of the pyrometer, holding it to an accuracy unheard of in work of this sort in the past.

In practical use, the instrument is held in one hand and the thermocouple tip applied to various portions of the mold or platen.

Temperatures of the mold may be taken at all points and should be checked against the desired temperature for the particular material being molded. It will frequently be found that different portions of the mold differ in temperature, which may be caused by a plugged steam channel in a semi-automatic mold or due to improper mold design as regards mass of metal to transfer the heat in the case of a hand mold. The platen itself in the latter case may have some plugged steam channels. Such reductions in temperature may also come from a slug of water or an actual physical obstruction, causing the temperature to be low.

The molding of various colored materials has also presented a temperature problem in that normal temperatures will frequently ruin the color of a light material. On many of the lighter greens and blues, it is found desirable to drop the temperature to 300° by any one of several means, and the Jewell Hot Molding Pyrometer will be found indispensable to the proper control of such molding.

Many difficulties with spongy sections which are improperly cured may be traced to lack of proper temperature control.

New Overload Switch for Small Motors

(Cutler-Hammer, Incorporation)

THE new switch is intended for use with industrial and domestic appliances and tools, including such equipment as washing machines, refrigerators, grinders, polishers, oil burners, etc.

It provides positive protection against motor burnouts due to overloads, prevents blown fuses and other electrical troubles caused by overloads. Push buttons furnish convenient starting and stopping control. The switch has a time limit type of thermal overload which is furnished in numerous ratings up to and including ¾ horsepower, 110 volts and 220 volts A. C., and ¼ horsepower 115 volts D. C. When an overload trips the switch, it is re-set by simply pressing the start button; this also restarts the motor. If the overload condition persists, the motor will not start, so that positive protection for the motor is assured at all times.

The switch will minimize troubles on motor driven appliances and tools caused by blown fuses, burned out motors or motor repairs in general which result from overloads.

Pattern No. 41 Ohmmeter

(Jewell Electrical Instrument Company)

THE Pattern No. 41 self-contained ohmmeter finds its greatest use in general laboratory work, in plants assembling electrical equipment, and in radio service. It is of the voltmeter type and includes the same magnetically shielded, high grade, direct current movement as used in other Pattern No. 41 instruments. A sub-base carries a three cell battery, making the instrument entirely self-contained and independent of an external voltage supply and far more convenient than even portable bridges, which, of necessity must occupy more space and weigh considerably more.

Accurately drawn scales are individually calibrated for each instrument. They are long and well lighted by the large scale opening. The knife edge pointer of the movement enables readings to be taken that are accurate within one degree of arc or 1% of the entire scale length. The best accuracy is had at or near the middle of the scale.

In use, the resistance being tested is connected between the terminals marked "Resistance," the button switch marked "test" depressed, and the value of resistance read on the scale.

The scales supplied as standard, have a figure at the left, namely, 5,000, 10,000, 20,000, or 50,000 ohms, these being considered as the highest resistance which can be satisfactorily measured with this instrument.

Current drawn from the standard three cell C battery in the base of the instrument is exceedingly low, being less than 15 milliamperes where the instrument reads to 5,000 ohms and considerably less in high resistance instruments. With ordinary use, the battery will last several months and may readily be replaced by removing the four screws from the base of the instrument.

Adjustments are made for battery voltage variation by a magnetic shunt controlled from the outside of the case by a knurled head. Before using, the binding posts are short circuited, the test button pressed, and the pointer adjusted to the top of the scale over a red line. This places the instrument in working condition and any resistance placed across the binding posts is then indicated on the scale. Since the adjustment is made each time a series of readings are taken, the instrument is usually more accurate than a voltmeter or ammeter for similar work.

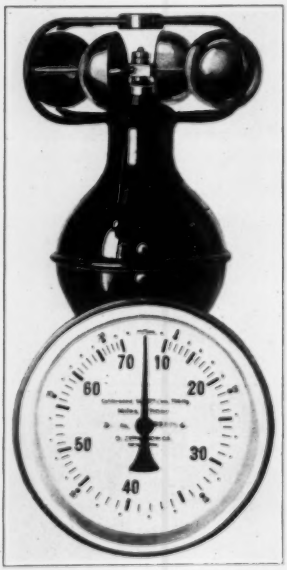
The radio service man will find one of the 10,000 ohm instruments of considerable value in his service kit for checking the various resistors in the power pack of the modern radio set; the instrument will withstand the hard service of being carried around from place to place and will at all times give accurate results. It cannot become burned out in service if no external voltage is applied; it can only be damaged by extreme abuse. In the railroad signal field, many measurements on signal apparatus, such as the selection of proper relay coils and ballast resistors, may be made with an instrument of this sort, usually using the 5,000 ohm scale, where the first division at the right represents 5 ohms.

While not intended to take the place of an accurate Wheatstone bridge, the instruments will at the same time be found to be sufficiently accurate for a large amount of ordinary resistance work.

Air Velocity Meter

(O. Zernickow Company)

THIS instrument is a combination of the "Robinson" Cup Cross and centrifugal tachometer. On the extension of the pendulum shaft, the cup cross is located. When exposed to an air current, the cup cross receives a very definite average angle velocity, in such a manner, that the average absolute speed of the cup center is in approximately constant relation to the wind velocity. The result is transmitted in the usual manner to the hand of the instrument and an accurate scale makes the reading of the wind velocity and its fluctuations very easy indeed. The reading is practically unaffected by altitude or barometric pressure and can, therefore, be used directly.



In order to make the O-Z Anemo Tachometer durable and rugged enough to stand up under the demands of severest service, all parts of the instrument, such as ball-bearing spindle, pendulum and indicating mechanism, are enclosed fully dust-proof in a strong and handy aluminum housing. The cross cups are protected by a wire guard. With the handle attached, the O-Z Anemo Tachometer weighs only 2 lbs. and can be used even in unfavorable positions.

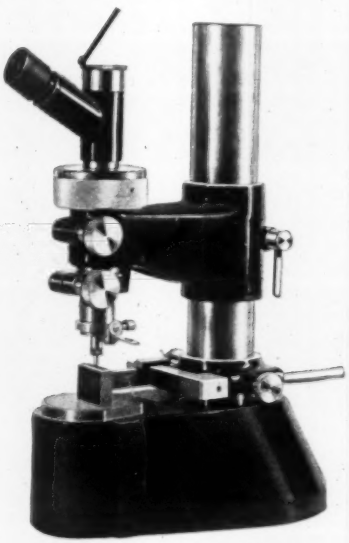
The very plain dial has double graduation, from 10 to 70 miles per hour and 5 to 35 meters per second. Other ranges and graduations can be made to order.

Optical Comparator

(Bausch & Lomb Optical Company)

THE demand of testing laboratories and inspection departments for a reliable indicator for comparison and measuring purposes to an accuracy of .00005" led to the development of the Bausch & Lomb Optical Comparator. The comparator can be used for measuring parts with flat surfaces, balls or cylinders.

Natural quartz has been selected as the material for the anvil upon which the work is placed. This material was selected for its greater hardness over steel, its low coefficient of expansion, its great durability in service and its resistance to oxidation.



A hardened steel ball $\frac{1}{8}$" in diameter is used as a contact point on flat surfaces, while in comparing balls or cylinders, the ball is removed and an adjustable hardened steel flat put in its place.

Two adjustments are provided to lower or raise the contact point. The entire arm which holds the contact point and scale device can be moved up and down on the vertical column for gross movements. A clamp on the side of the instrument locks the arm in position. The comparator gage is locked to the arm by a screw. Fine adjustment can be made by the large knurled sleeve just above the arm, and a lock screw will clamp the gage after the fine adjustment has been made.

The instrument with its delicate parts is built into a strong steel casing and is well designed to withstand the rough usage in the workshop.

In using this instrument the measurements are checked with standards. The standard gage block is placed upon the anvil of the comparator and the contact point is brought against the upper surface of the block. By means of the gross adjustment the index is made to coincide approximately with the zero line of the scale. By means of the fine adjustment which is located just above the arm, the exact adjustment is made so that the scale registers precisely zero. Then by removing the standard gage block and placing the work on the anvil under the contact point, the operator can glance into the eyepiece and instantly see whether the work is within the prescribed limits of tolerance.

The contact point can be lifted $\frac{3}{32}$" above the object, thus making it convenient to place or remove the work. The range of the calibrated scale is ±.0004". Objects can be compared up to six inches in height.

The pressure applied when operated in a vertical position is approximately three ounces.

The optical comparator is supplied in two models: the No. 4960-A which has an eyepiece which is 60° inclined to the measuring axis and the No. 4960-B with a 90° eyepiece.

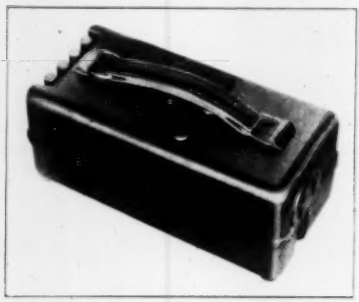
It is also possible to supply the No. 4960-A with a projection attachment which enables the operator and even one or two other persons to observe the reading at the same time, with both eyes and without the discomfort of peering through an eyepiece.

This attachment is particularly recommended when large quantities of duplicate pieces are being inspected because of its convenience and elimination of eye strain.

The Paragon Megohmer

(Herman H. Sticht & Company)

The Measuring System. This is of the differential type, with three coils, one series coil, one shunt coil, and one compensating coil which assures proper scale characteristics. The construction is entirely new and novel. Due to the use of more powerful magnets than have ever been used in instruments of this type, the coils are shorter and mounted symetrically on the shaft. This means a well-balanced moving system that is more rugged than some of the older types of differential systems. This also makes possible the elimination of leveling screws and the use of the more convenient rubber feet on all but the highest range instrument, 0-10,000 megohms. The whole measuring system, complete with magnet, is mounted in a special dust and fume proof light weight alloy housing. The protective and shunt resistances totaling over 800,000 ohms are wound on porcelain spools and mounted under this housing, which is readily removable from the instrument case.



The Generator. This is a self-contained unit. At the crank handle end are the fibre gears assuring complete elimination of the rasping noise generally associated with small gears of high ratio. Next to the gears and in the same section of the generator housing is the improved type centrifugal clutch, assuring constant voltage at speeds in excess of 120 R. P. M. of the crank handle. The commutator also embodies a number of new features; the brush holders are assembled into a complete unit, just as in the modern generator, with adjustable rocker, to assure perfect commutation. The generator has four powerful permanent magnets, mounted externally to the generator housing and in a manner to assure maximum efficiency.

The Case. The two units—the generator and the measuring systems—are enclosed in a well-designed composition case. This assures an instrument which is rugged enough to meet the requirements for an instrument of this type and at the same time assures a permanent finish in keeping with the quality of the instrument. The binding posts, which are of a new spring locking type, are mounted in a recess in the case so that they are not subject to breakage. The caps of the binding posts are insulated so that the operator of the instrument is protected from shock when using the instrument.

Optical Thickness Gage

(Bausch & Lomb Optical Company)

THE knowledge concerning wall thickness of transparent material, such as glassware, centrifuge sedimentation tubes, electric light bulbs, internally frosted bulbs, radio transmission tubes, radio power tubes, sheet glass, glass tubes, and other products of the glass and transparent celluloid industry, is in many instances of great importance. Glass tubes, etc., must often withstand either high pressure or high vacuum within margins of safety, for the safety of the user and for economical production.

The principle of the optical thickness gage is based on the laws of reflection and refraction. Transparent material with either two polished or glazed surfaces may be readily measured.

The schematic drawing shows how with the aid of the light source at L, the image of the graduated glass scale S is projected by the lens M on the first surface A of the glass plate or glass bulb when held against the small elongated aperture O. This aperture is at an angle of 45 degrees to the beam of light.

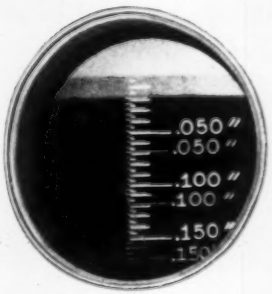


FIG 2

Left: The two scales as reflected into the eye-piece when measuring glass approx. 0.018" thick.

Right: Schematic diagram of the optical system.

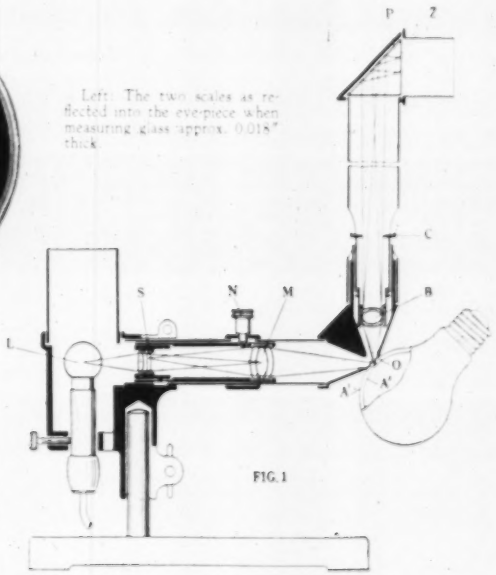


FIG. 1

Surface A^1 located in the focal point of the lens M will reflect the image of the scale S toward the lens B which will relay the image through the prism P on to the frosted screen Z.

According to the laws of optics a certain percentage of the light from the source L is reflected at A^1, while the balance of the light is being refracted into the transparent material. This refracted portion of the light will fall on the second surface A^2 and be partially reflected toward the surface A^1, from where it is refracted into the air toward the lens B which will relay this second image of the scale S through prism "P" on to the screen Z.

When the object is held against the aperture O, two scale images become

visible on the screen. These are of almost equal light intensity and the vertical separation of the two scale images is proportional to the separation of the two glass surfaces of the object. (See inset 2)

The separation of the overlapping images may be measured directly by counting the divisions from the first horizontal boundary line on top to the second boundary line.

This instrument is adjusted to a test glass (furnished with the instrument) having an index of refraction N = 1.522. But the instruments can be adjusted to the refractive index of any transparent material.

The portable (pocket size) optical thickness gage is built on the same principle as the bench type, but depends upon an outside light source for illumination of the scale. It measures the thickness of common glass (of a refractive index N = 1.522).

The instrument cannot be adjusted to measure glass of unusual refractive index but the difference can readily be computed mathematically if the index of refraction is known.

A gage can be furnished for a special index of refraction.

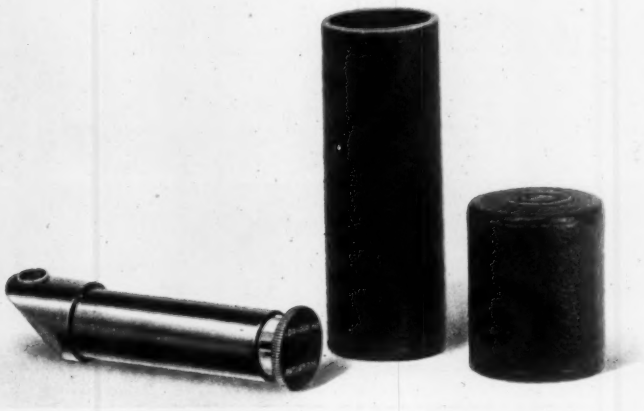


FIG. 3. Portable Pocket Size Optical Thickness Gage.

New Series of Stereoscopic Photographs of Crystal Models

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ACCESSORIES FOR SPECTROMETERS AND SPECTROGRAPHS. 44 page bulletin contains information on various accessories' condensers, absorption tubes, slits, micrometer eyepieces, vacuum pumps, rare gases, rare metals, thermopiles, photo electric cells, etc. Adam Hilger, Ltd., 24 Rochester Place, Camden Road, London, N. W. 1., England.

ANALYTICAL PRECISION FOR THE RESEARCH LABORATORY. This is the title of a 104 page booklet, which contains information on the following instruments: Colorimeters, Nephelometers, Hemoglobinometers, Scopometers, Refractometers, Spectroscopes, Polariscopes. Bausch & Lomb Optical Company, Rochester, N. Y.

AUTOMATIC TEMPERATURE CONTROLLERS. Booklet, 12 pages contains illustrations of automatic controller installations. Wilson Maeulen Co., 387 Concord Ave., New York, N. Y.

AC-ME SPECIALTIES FOR THE GAS AND GASOLINE INDUSTRIES. Special instruments for the gas and gasoline industries are described and illustrated. Refinery Supply Co., 621 E. 4 Street, Tulsa, Oklahoma.

APPARATUS FOR THE PREPARATION AND EXAMINATION OF MINERAL SPECIMENS. Five multigrapned bulletins describing the cutting, grinding and polishing machines for mineralogical sections. E. Leitz, Inc., 60 East 10 Street, New York, N. Y.

BRDIGE-MEG. Circular 515 describes device for making electrical resistance measurements up to 100 megohms. James G. Biddle, 1211 Arch Street, Philadelphia, Pa.

CALORIMETER. Bulletin describes and gives method of operation of the Union Recording Calorimeter. This is printed in German. Union Apparatebaugesellschaft, Karlsruhe Badeb, Germany.

CONDENSATION METERS. Bulletin 402 covers the rotary condensation meter; Bulletin 404 covers the "Simplex" condensation meters. American District Steam Company, North Tonawanda, N. Y.

CARBON DIOXIDE METERS. Bulletin 781 is a 24 page booklet describing the L & N Electrical Carbon Dioxide Meters. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

ENGINE-TEMPERATURE INDICATOR. GEA 1187B describes an aircraft engine temperature indicator. General Electric Co., Schenectady, N. Y.

FLOW METER. Large direct mail folder illustrates applications of the Brown flow meter in various industries. Brown Instrument Company, 4488 Wayne St., Philadelphia, Pa.

FLOW METER-STEAM. Bulletin is devoted to the St. John Steam Flow Meter. American District Steam Company, North Tonawanda, N. Y.

GALVANOMETERS. Revised Edition of Catalog No. 20, 40 pages. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

GAS SERVICE JOURNAL. The February issue contains the following articles: Miniature Coke Ovens to Serve Small Communities; Emco Gas Meters at the Denver Fire Clay Company; New Developments in Flood Lighting; Factors in Buying. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

HIGH REVOLVING POWER INSTRUMENTS. 24 page leaflet contains information on the Fabry Perot interferometers; the Fabry-Perot Etalons; Lummer Gehrke Plates; Michelson-Transmission Echelon Gratings and Williams Reflections Echelon Gratings. Adam Hilger, Ltd., Camden Road, London, NW 1, England.

INSTRUMENT INVESTMENT NEWS. The March issue contains the following articles: Felt Hat Making Dependent Upon Instruments; American Precision Temperature Controller now made in Large Sizes; Western Union Keeps Close Temperature Control; Pacific Coast Well Served by Western Engg. Co. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

IGNITION TESTER. Leaflet describes the Union Ignition Speed Tester. This is printed in German. Union Apparatebaugesellschaft, Karlsruhe, Germany.

LATHES. Bulletin No. 9 describes new model 9 inch lathe; Bulletin 15 new model 15 inch lathe; General Catalog No. 91-A is a 108 page book giving descriptions and illustrations of 96 sizes and types of precision lathes. South Bend Lathe Works, South Bend, Indiana.

LIGHTNING. This is the title of a publication, which gives an account of the lightning investigations made by the Westinghouse Co. Circular 1737-E. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

MAGNETO COMPASS. GEA-1175A describes a magneto compass for aircraft. General Electric Company, Schenectady, N. Y.

OIL BURNER CONTROLS. Bulletin describes oil burner controls for household furnaces. Basel Mfg. Co., Merriam, Kansas City, Kansas.

HARDNESS TESTERS. Leaflet illustrates Precision Hardness Testing Machine and new style Brinell Calibrator. Pittsburgh Instrument & Machine Co., 1026 Reedsdale St., Pittsburgh, Pa.

PRECISION THROUGH OPTICAL METHODS. 20 page booklet describes various precision optical measuring instruments. Bausch & Lomb Company, Rochester, N. Y.

GENERAL RADIO EXPERIMENTER. The February issue of the General Radio Experimenter contains an article on Piezo-Electric Quartz Plates. General Radio Co., Cambridge A, Massachusetts.

HYDROGEN ION CONTROL. List No. 600 contains information on comparators for hydrogen ion control. Hellige-Klett, Inc., 179 East 87 St., New York, N. Y.

ILLUMINATOR AND TEN FOOT SCALE FOR GALVINOMETERS. Leaflet illustrates and gives prices. Leeds & Northup Company, 4901 Stenton Ave., Philadelphia, Pa.

INSTRUMENTS FOR MINES AND SAFETY. Catalog No. 4 is a general catalogue. Instruments are illustrated for lamp testing, moisture testing, gas testing altimeters, anemometers, barometers, etc. Mines Safety Appliances Co., Braddock Ave. & Thomas Blvd., Pittsburgh, Pa.

LABORATORY EMERGENCY CHART. Chart gives directions for procedure in case of lavoratory accidents, poisoning or injury by corrosive chemicals. Free to laboratories. Fisher Scientific Co., 711 Forbes Street, Pittsburgh, Pa.

AUTOMATIC CONTROLLER CATALOG. Catalog No. 900B features Tag round form controllers, lists and describes indicating, non-indicating and recording controllers for temperature, pressure, temperature-humidity, time, condensation and liquid level. C. J. Tagliabue Mfg. Co., 18 Thirty-third St., Brooklyn, N. Y.

LEVELS. Leaflet illustrates various types of levels: box levels, plain levels, etc., this is printed in English. F. Mollenkopf, Torstr. 10, Stuttgart, Germany.

NEW TOOLS. Supplement to Catalogs 31 and 139 illustrates several of the recent additions and improvements to Brown & Sharpe Tools. Brown & Sharpe Mfg. Co., Providence, R. I.

MEGOHMER. Preliminary Leaflet No. 190 describes the new Paragon Megohmer. Herman H. Sticht & Company, 21 Park Row, New York, N. Y.

PRECISION THROUGH OPTICAL METHODS. This is the title of a 20 page booklet devoted to several precisions optical instruments for machine shop use. Bausch & Lomb Optical Company, Rochester, N. Y.

REMOTE TYPE INSTRUMENTS. Catalog 7501 shows in detail the operation of the various instruments. Sectional views and wiring diagrams amplify the descriptive material. Brown Instrument Company, 4482 Wayne Street, Philadelphia, Pa.

SPECTROGRAPH. Mimeographed folder describing the B & L New Universal Spectrograph. Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.

SURVEYING ACCESSORIES. Leaflet describes the three piece Frisco level rod, an improved right angle mirror, a co-ordinate spacer and a temperature tape corrector. Brandis & Sons, Inc., 754 Lexington Ave., Brooklyn, N. Y.

TALLY METER. Leaflet illustrates a device for measuring lumber. Tally-Meter Co., Norwich, Conn.

THEODOLITE AND TACHYMETER. Sonderliste 150 illustrates repetition theodolites and transits. This is printed in German. Gustav Heyde, Dresden, N. 23, Germany.

TRANSFORMER THERMOMETERS. Leaflet illustrates the Model T-1 transformer thermometer. Motometer Gauge & Euipment Co., Long Island City, N. Y.

WHEATSTONE BRIDGES. 4 page leaflet illustrates various types of wheatstone bridges. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

OHMMETERS. Leaflet describes the Pattern No. 41 Ohmmeter. Jewell Electrical Instrument Company, 1650 Walnut Street, Chicago, Ill.

HOT MOLDING PYROMETER. Leaflet describes the Jewell Hot Molding Pyrometer. Jewell Electrical Instrument Company, 1650 Walnut Street, Chicago, Ill.

RADIO INSTRUMENTS. Bulletin covers set and tubes testers, voltmeters and ammeters, etc. Readrite Meter Works, Bluffton, Ohio.

INSTRUMENT FOR RECORDING THE THICKNESS OF SHEET MATERIALS. Leaflet describes and illustrates an instrument for recording the thickness of materials. Bulletin 130, Esterline-Angus Co., Indianapolis, Ind.

THE LABORATORY. Volume Three, Number One of this house organ contains an interesting editorial entitled "Time" which has brief historical references to time measurement; a description of a spectroscope. Technical Service Department, Fisher Scientific Company, 711 Forbes St., Pittsburgh, Pa.

PYROMETER RECORDER. Folder describes the Model 28 Super Pyrometer Recorder for two, four and six records. Thwing Instrument Company, 3339 Lancaster Ave., Philadelphia, Pa.

UNIVERSAL TEST INDICATOR. Leaflet illustrates the "Last Word" Model F universal test indicator. H. A. Lowe, 1874 East 66 St., Cleveland, Ohio.

GAGE BLOCKS & ACCESSORIES. 48 page booklet contains very interesting information on gage blocks and their applications. C. E. Johnson, Inc., Division of Ford Motor Co., Detroit, Mich.

GAGES FOR PRESSURE AND VACUUM. Catalogue No. 300 contains information and illustrations on various types manufactured by J. E. Lonergan Co., 211 Race St., Philadelphia, Pa.

TEMPERATURE CONTROLS. Loose leaf folder gives information on temperature controls for industrial and commercial gas fired appliances. Partlow Corp., Utica, New York.

PYROMETERS. Catalog L3 is a complete catalogue of pyrometers of recording, indicating and automatic controlling types. Wilson-Maeulen Company, 387 Concord Ave., New York, N. Y.

PHOTOELECTRIC SPECTROPHOTOMETER. Bulletin 101 describes and illustrates the instrument. American Photoelectric Corp., 149 Broadway, New York, N. Y.

POWER CABLE FAULT BRIDGE. Bulletin 536 describes an instrument for locating a fault in a cable by the Murray Loop method. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

SPECTROSCOPY IN CONTROL OF PURITY IN FOOD STUFFS. Leaflet briefly considers emmision spectrography. Adam Hilger, Ltd., Camden Road, London, NW 1, England.

SECONDS STOP-RECORDER. Leaflet illustrates instrument. Glogau Co., 538 So. Clark St., Chicago, Ill.

TECHNICAL INSTRUMENT BULLETIN. The February issue contains the following: New Methods of Episcopic Projection; The Creation of a Microscopic Objective; A New Daylight Laboratory Lamp. Emil Busch Optical Co., Ltd., Hatton Garden, London, EC1, England.

WATER WORKS JOURNAL. The February issue contains: History of Winooski Water Works; Improving Water Works System of Scotia, N. Y.; A Short History of the Purification of Water. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

PRECISION INDUSTRIAL RECORDERS AND CONTROLLERS. Reprint from Journal of the Franklin Institute. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

OIL METERS. Bulletin 125 fully describes and illustrates the Empire oil meter—a positive displacement meter with an oscillating piston measuring unit. National Meter Co., 299 Broadway, New York, N. Y.

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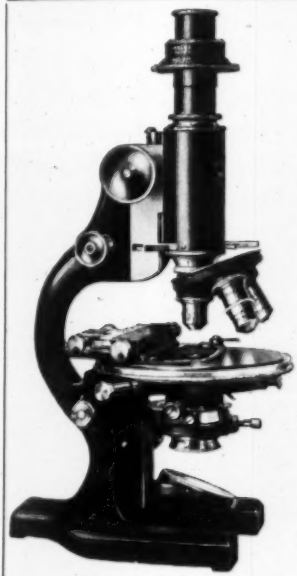

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CURRENT LITERATURE REVIEW

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ELECTRICITY

New G. E. C. Developments. Electrical Review, Jan. 10, 1930, page 88.

Describes the "Magnet" cell-testing voltmeter of the General Electric Co., Ltd., London.—M. S.

Instrument Transformers. J. G. Wellings & C. G. Mayo. Electrical Review, Jan. 10, 1930, pages 89-90.

Extract from paper before Meter and Instrument Section of the Institution of Electrical Engineers. General review of the subject and an outline of the authors' work on design dealing particularly with current transformers. Have developed means by which the errors of a current transformer are no longer merely a function of the losses incurred in producing flux in the core, but may be compensated for and the accuracy of the transformer maintained, though the losses may be relatively high.—M. S.

Electricity Meter Testing. Chas. J. Webb. Electrical Review, Jan. 17, 1930, pages 108-110.

Account of the recently completed laboratory of the Compagnie Parisienne de Distribution d'Electricite.—M. S.

Electricity Meters. E. W. Hill. Electrical Review, Dec. 20, 1929, page 1117.

Extract from address before Meter and Instrument Section of the Institution of Electrical Engineers. Discusses some of the things which appear to be wrong with present methods of measuring electrical energy. Meters are inefficient and could be made more accurate. Progress has been made in economy of material and space and in design.—M. S.

Alternating Current Potentiometers. C. V. Drysdale Electrical Review, Dec. 27, 1929, pages 1165-1166.

Abstract of paper before the Meter & Instrument Section of the Institution of Electrical Engineers. Discusses theory, evolution, accuracy, construction, and applications for testing purposes. The Drysdale-Tinsley, Gall, and Campbell-Larsen instruments appear to be the only ones suited for general testing. Refers especially to his own potentiometer.—M. S.

Absolute Method of Measuring High Frequency Currents. R. L. Smith—Rose. Nature, Oct. 26, 1929, pages 651-652.

Author describes measurement of currents by their heating effect in mercury threads in glass tubes.—Abs. Bull. Kodak Res. Labs.

The Errors of Watt-hour Meters at Low Load and Low Power-Factor (Die Fehler der Elektrizitaetszaehler bei kleinen Belastungen und niedrigem Leistungsfaktor) Kelbe & Fuhrmann. Messtechnik, Jan. 1930, pages 6-9.

Discussion of an article by W. Fuhrmann appearing in Messtechnik, Sept. 1929, pages 244-248.

Electrical Power Booster (Elektrischer Leistungs verstaeker) G. Schuetzler. Messtechnik, Oct. 22, 1929, pages 275-278.

A proportional power booster for indicating and recording small electromotive forces is described.

Testing Conventional Circuits. Part 3—The Power Unit. Radio Service, March 1930, pages 11-12.

Instruments required and methods are given.

Increasing the Range of Ammeters and Milliammeters. Aerovox Wireless Corp. Radio Service, March 1930, pages 13-15.

The internal construction of the meter is described and circuits for increasing the range are illustrated.

A Discussion on Set Analyzers. Radio Service, March 1930, pages 6-7.

The application of a modern test set in service work is discussed.

Impedance Bridges. S. J. Zammators. Bell Laboratories Record, Dec. 1929, pages 167-170.

The comparison, resonance, and Owen bridges constitute the more important types of bridges employed in the laboratories and manufacturing department of the Western Electric Co. for testing impedances. The specific conditions of the tests determine which of these 3 types is most suitable for obtaining the desired measurements.

A New Type of Self-Balancing Potentiometer. F. Moore. Review Scientific Instruments, March 1930, pages 125-139.

A very complete description of the New Wilson-Maculen potentiometer recorder.

A New Portable Test Instrument for Transformers. (Eine neue tragbare Stromwandler Prueferinrichtung) O. Lieber. Siemens Zeitschrift, Dec. 1929, pages 845-850.

The theoretical basis of the new instrument is given, the instrument, its application is described and the accuracy of the measurements were tested.—G. N.

Contribution to the Mathematical Theory of the Measurement of Inductances (Contribution a la theorie mathematique de la mesure des inductances). Angelina Cabras. Revue Generale de l'Electricite, Dec. 14, 1929, pages 959-963.

Presents the mathematical theory of the Wheatstone bridge in the case where it carries currents of variable intensity and of any form, and its branches consist of any complex impedances.—M. S.

Inexpensive Method of Locating Cable Faults. E. R. Pelster. Electric Light & Power, Feb. 1930, pages 60-66.

Dallas Power and Light Co. has developed fault location apparatus comprising a 10 amp. 4,000 volt reactior and a 15 kva. 4,000 230-460 volt transformer mounted on a small platform on wheels, voltmeter, ammeter, switch, special split core transformer, and special exploring coil.—M. S.

Scales of the Electric Service Company. C. P. Townsend. Electric Light & Power, Feb. 1930, pages 62, 64, 66.

Discusses and illustrates the necessity of checking meter installations so as to eliminate errors in billing customers.—M. S.

Special Device Simplifies Radio Interference Tests. C. M. Lindsley. Electrical West, Jan. 1, 1930, page 20.

Southern Sierras Power Co. has developed a portable instrument for locating radio interference sources along its high voltage lines. Comprises a recalibrated, reversed-scale, milli-ammeter, giving direct reading in ohms, a variable resistor, a small 90-volt battery, and a multipoint battery switch. Extension leads are carried in a small compartment.—M. S.

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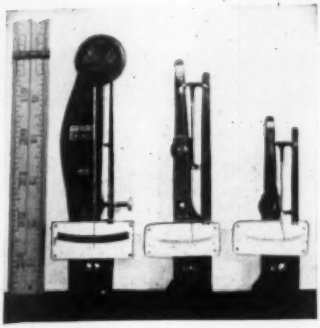

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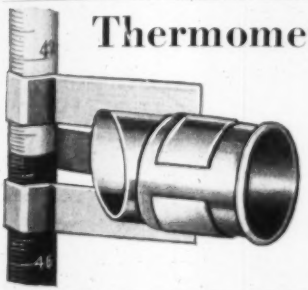

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SPECIAL

New Method for Measuring the Instantaneous Angular Velocity of a Body Rotating at High Speed. O. Okoshi; Bulletin Institute of Physico—Chemical Research (Tokyo), Aug. 1929, 7 pages.

A falling camera method is used. The variation in angular velocity of a reciprocating engine throughout a cycle was easily measured by this method.—Abs. Bull. Kodak Research Labs.

Recording of Rapid Pressure Oscillations by the Method of the Half-Resonance Curve (Aufzeichnung rasch verlafender Druckvorgaenge mittels des Verfahrens der halben Resonanzkurve). Kurt Schnauffer. Luftfahrtforschung, Feb. 14, 1930, pages 126-136.

Due to the fact that the mechanical instruments used at present for measuring the rapidly changing quantities, as for instance amount of air, pressure in cylinders and manifolds etc., do not at all give a proper view of the actual happenings in high speed air-plane motors the author applied and modified an electrical measuring method which resulted in a continuous record of pressure, torsion and bending phenomena free of distortions; this method was first used by Riegge-Trendelenburg for recording of acoustic phenomena. The results of investigations and tests with this instrument are reproduced in numerous indicator and other diagrams; calibrations and evaluation is described, and a modification of a bar-spring indicator is discussed which facilitated the elimination of several disturbing factors due to oscillations of the system.—H. A.

Recent Developments in Aircraft Instruments. S. J. Zand. Paper read before Pittsburgh Aeronautical Meeting, American Society Mechanical Engineers, March 12, 1930.

This paper describes briefly some of the more recent developments in aircraft instruments and shows how these instruments may be made legible, accurate and reliable, and at the same time small and light in weight. Instruments considered are: passenger altimeter, sensitive altimeter, distant indicating tachometer, the engine-gage unit, and the remote-control magnetic compass.

A New Recording System for Measuring Instruments. (Un nouveau systeme d'enregistrement pour appareils de mesures). P. J. Savary. Revue Generale de l'Electricite, Dec. 28, 1929, pages 1039-1042.

Describes a device known as the "sparkography." It is based on recording the movements of the pointer of a measuring instruments by means of a spark which jumps between the pointer acting as an electrode and a second electrode. A sheet of special paper sensitive to the spark is inserted between these 2 electrodes. The spark being due to a voltage at high frequency, the aggregate of the points tracing the passage of the spark constitutes a continuous curve representing the recorded diagram. The device can be adapted to all measuring instruments provided with a pointer.—M. S.

Some Industrial Tests on Refractory Materials. W. H. Simmons. Industrial Chemist, Aug. 1929, pages 338-341.

An account of apparatus devised by Drs. Endell and Steger of the Technische Hochschule, Berlin. An apparatus for determining refractoriness under load is arranged so that a constant load is applied to the test piece which is gradually heated to 1700°C. The expansion is automatically recorded. An instrument for measuring the thermal expansion up to 800°C. automatically records the differential expansion between a fused quartz tube and the specimen plus two quartz rods which grip it. For measuring the thermal expansion up to 1,600°C., the heated specimen is observed by means of two parallel telescopes, the expansion being noted on the eyepiece scales. An equipment for the spalling test of bricks has been devised to give a quantitative determination of the power of refractories to withstand sudden changes of temperature.—Abs. Bull. Kodak Res. Labs.

Testing Welds with Stethoscope. Oxy-Acetylene Tips. Vol. 8, Jan. 1930, pages 127-128.

Stethoscope testing of welds is non-destructive and can be applied to plate, pipe joints or structural steel joints with equal facility. Procedure in testing is given.—M. L. M.

Application of the Inverse Wiedemann Effect to Torque Measurements and to Torque Variation Recordings. T. Kobayal, K. Simamura & T. Koyama. Report No. 52, Aeronautical Research Institute, Tokyo Imperial University, Nov. 1929, pages 425-445.

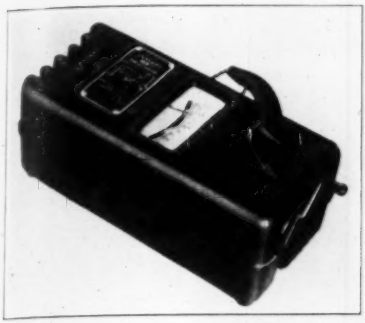
The effect produced by twisting iron rods 2-2.5 cm in diameter are studied. The torque variations of an automobile engine are measured and recorded by an oscillograph.

The Principles of Seismic Prospecting. L. Don Leet. Presented at the last meeting of the Eastern Section of the Seismological Society of America.

The term "Seismic Prospecting" is usually applied to the study of subsurface geologic structure by means of elastic waves set up by dynamite blasts and recorded on tromometers, following the general theory of seismology. The greater part of such work, however, has had for its more limited objective the location of salt domes as favorable structures for the accumulation of oil. The discussion presented, where it involves field procedure, is confined to this type of prospecting, with special emphasis on one of its most recent developments—work over water-covered areas. The purpose is to consider general principles. The subject is introduced by a history of the problem, followed by the geological history of the gulf coastal plain; the problem of locating salt domes; the introduction of seismic methods; a discussion of the theoretical basis for seismic prospecting, of field methods, and of results and costs. Accepting salt dome prospecting as a closed field, for the moment, certain features are discussed pertaining to the possiblities of the seismic method for the exploration of subsurface conditions which might lead to quantitative data on other structures than salt domes. Six points are mentioned. Some or all of them may have been met by companies in the field, but if they have, a veil of secrecy cloaks the results. In conclusion, consideration is given to the possible sources from which aid may come for the future development of the theory of the method. Whatever the means ultimately made available, the matter should engage the interest of all seismologists, if for no other purpose than the protection of the science's good name. There are many things being done in its name for which seismology should be none too eager to claim or admit responsibility.

Development of Modern Methods of Testing Lubricating Oils. J. C. Jennings. Journal Society of Chemical Industry, Nov. 15, 1929, pages 1104-1109; Nov. 22, 1929, pages 1128-1132.

The evolution of modern methods of testing lubricating oils is described, detailed descriptions being given of methods of determining viscosity, cold test, coking test, demulsibility, and oiliness. One of the main causes of oil deterioration is oxidation, stability tests being a more or less direct estimation of the results of oxidation. The many tests described are subdivided into three main groups: (1) those measuring the degree of unsaturation of the original oil; (2) those in which the heated oil is subjected to oxidation for a definite period and then examined by various methods; and (3) those in which the time is noted for certain deterioration effects to take place. A standard English test is the Michie sludge test, which is discussed in detail.—Abs. Bull. Kodak Res. Labs.



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When writing to the above companies, please mention INSTRUMENTS

Instruments in Industry. W. E. Hardy. Instrument World, Jan. 1930, pages 243-244.
A brief elementary discussion of possible instrument applications. It is really an appeal to British industry to use more instruments. The article states "The manufacture of industrial instruments in Great Britain has not progressed so speedily as in certain other countries, notably Germany and the United States."

Automatic Control in Gasworks. J. W. Morris. Instrument World, Mar. 1930, pages 293-295.
This article deals with the industrial applications of instruments and control apparatus.

Pacific Goodrich Rubber Company Laboratories. W. D. Morgan. Rubber Age, Mar. 10, 1930, pages 592-594.
This article describes the tests and controls over all raw materials before release to the mills. General layout and floor plans follow the general scheme of straight line production as found in the main factory.

Better Electric Appliances Bring Better Service to Our Customers. Detroit Edison Synchroscope, Mar. 1930, pages 1-7.
Describes the testing of various electrical appliances.

Safety! Rubber Goods Tests. J. C. Hummel. Electric Light & Power, Feb. 1930, pages 42-45.
Union Gas and Electric Co. has installed complete apparatus for performing both acceptance and routine tests of rubber goods. These include device for determining glove size, micrometers for measuring thickness, tensile testing machine, machine for making dielectric tests of gloves, line hose and insulator hood testing machine, and blanket, mat, and stool testing machine.—M. S.

Automatic Distance Regulation of Hydraulic Engines in the Achensee Power Station (Die automatische Fernregulierung der Wasserkraftmaschinen im Achenseekraftwerk der Tiroler Wasserkraftwerke A. G.). H. Latzko and O. Plechl. Electrotechnik und Maschinenbau, Wien, Sept. 8, 1929, pages 791-797.
Paper presented at the Elektrotechnische Gesellschaft Vienna, gives the instruments and their connection diagrams and actual service.—M. S.

MICROSCOPY

Contribution to the Microscopy of the Vulcanization of Rubber. E. A. Hauser & M. Huenemuerder. Le Caoutchouc et la Gutta—Percha, Sept. 15, 1929, pages 14146-14149.
The literature dealing with microscopical studies of the vulcanization of rubber is reviewed. An apparatus is described by means of which rubber may be studied under a microscope while vulcanization is in progress. The results of such a study of typical mixtures of rubber with sulfur, accelerators and zinc oxide are discussed.—Abs. Bull. Kodak Res. Labs.

New Study of the Micrography of Paint Films. E. Stern. Farbe und Lack, Nov. 21, 1929, pages 560-563.
Photomicrographs and descriptions of the characteristic form taken by various mixtures of linseed oil, stand oil, wood oil, rubber, are given.—Abs. Bull. Kodak Res. Labs.

Hints From a Photomicrographic Notebook. T. S. Curtis. Educational Focus, Sept. 1929, page 4.
A thoroughly practical discussion on points of technic and standardization in the production of photomicrographs as practised in the Research Laboratories of the Vitrefrax Corporation.—Abs. Bull. Kodak Res. Labs.

Ultra-Violet Microscopy. J. E. Barnard. Nature, Aug. 17, 1929, page 281.
The author advises the use of the cadmium radiation at 275 mμ. Magnalium he finds to be the most satisfactory reflector for ultra-violet light. An ultra-violet dark-ground illuminator built of magnalium with fused quartz lens is being produced. With this apparatus and a quartz objective striking results are obtained.—Abs. Bull. Kodak Res. Labs.

Methods in Metallurgical Research. Part II. Walter Rosenhain. Heat Treating & Forging, Dec. 1929, pages 1579-1582.
Paper read before Institute of Metals, Sept. 1929. This part is devoted to microscopic examination and X-ray methods.—M. S.

TEMPERATURE & MOISTURE

Optical Pyrometer for the Iron Industry. (Optisches Pyrometer fuer die Eisenindustrie). Zeitschrift Verein deutscher Ingenieure, Oct. 12, 1929, pages 1460.
This pyrometer of the Pyro-Werk Dr. R. Hase, Hannover, compares the brightness of the body whose temperature is to be measured with the brightness of a little mark. The latter is illuminated by a small electric bulb and its brightness remains constant during the measurement while the brightness of the other body is dulled by a smoke glass wedge until the mark disappears. This method has the advantage that the measurement is always made at the same brightness and therefore independent of the temperature. The divisions are such that an accuracy of 5°C can be obtained.—Ha.

New Thermoregulator: Improvements. S. C. Collins. Journal Physical Chemistry, Nov. 1929, page 1850.
A thermoregulator is described which operates upon the principle of differential expansion of air and the saturated vapor of some liquid.—Abs. Bull. Kodak Res. Labs.

Wollaston Wire and Foil and Their Uses as Resistance Thermometers. E. Waetzmann, O. Grielinski & H. Heizig. Zeitschrift fuer Physik, Nov. 1929, pages 449-469.
An electrical method recommended by Friese and Waetzmann for handling wollaston wire has been thoroughly tested. This method gives good results. The wire and foil were examined electrically and under the microscope. A number of samples were made into resistance thermometers.—Abs. Bull. Kodak Res. Labs.

Temperature Control. Lubrication, Oct. 1929, pages 109-118.
A discussion of the maintenance of the most effective lubricating viscosity.

Temperature Measurements in Molten Aluminum and its Alloys. K. Marsh. Transactions American Society Steel Treating, Feb. 1930, pages 275-280.
Data sheet for Institute of Metals Division of A. I. M. E. and Recommended Practice Committee of the A. S. S. T.

Siemens Temperature Controlling Stations in Modern Refrigerator Plants (Siemens-Temperaturüberwachungsanlagen in neuzeitlichen Kuehlhaesern) Siemens Zeitschrift, Jan. 1930, page 66.
Brief description of temperature controlling instruments as installed in a cold storage warehouse for eggs in Berlin-Osthafen.—G. N.

Temperature Measuring Instruments in a Meat Packing Plant. (Waermetechnische Messgeräte im Betrieb einer Fleischwarenfabrik) Siemens Zeitschrift, Jan. 1930, pages 66-67.
Illustrated Description.—G. N.

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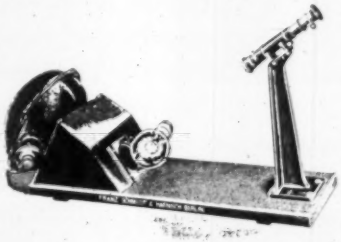

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A New Pocket Pyrometer. (Ein neues Taschenpyrometer). Giesserei-Zeitung, Nov. 1, 1929, page 610.
The pyrometer, invented by G. Naser, Kaiser Wilhelm Institut fuer Eisenforschung and made by Stroehlein & Co. Duesseldorf, a precision color glass with increasing color density. In sighting a hot specimen the change of color of a light filter from red to green is indicated by a mixed color nearly white, which gives the temperature of the specimen. The instrument offers many advantages in comparison to the known pyrometers.—G. N.

Temperature Control to the Heat Treating Plants. (Temperaturueberwachung im Haertereibetrieb). W. Jaeckel. Siemens Zeitschrift, Nov. 1929, pages 807-813.
Temperature control instruments, as thermoelectric, and radiation pyrometers, as well as recording instruments are described and illustrated.

New Thermionic Relay. Electrical Revue, Nov. 8, 1929, page 833.
Describes a thermionic relay produced by Baily Grundy & Barrett, Ltd., particularly for use in connection with temperature control apparatus requiring control within .01 deg. C.—M. S.

New Surface Pyrometers. Electrical Review, Nov. 1, 1929, page 785.
Describes the "Cambridge" surface pyrometers which are claimed to provide accurate and convenient means for quickly determining the inside surface temperatures of bakelite and other molds and of the heated surfaces of mold presses.—M. S.

COMBUSTION AND HEAT UNITS

Determining Thermal Conductivity of Heat Insulating Materials. H. Stiles. Chemical Metallurgical Engg., Oct. 1929, pages 625-626.
Describes apparatus designed and procedure for testing heat insulating properties of wallboard. Apparatus consists essentially of a boiler and an ice container between which the specimen is clamped. The ice container is divided into two compartments, the outer serving as a guarding.—M. S.

Automatic Combustion Control. C. H. S. Tupholme. Electrical Review, Nov. 29, 1929, pages 942-943.
Describes some features of the system adopted at the Edgar generating station, Boston. Equipment has been installed by the Bailey Meter Co. The system changes the supply of fuel and air to all boilers simultaneously in response to changes in steam pressure.—M. S.

Tantalum Proves Economical for Calorimeter Body. G. C. Maier. Chemical and Metallurgical Engineering, Sept. 1929, page 553.
Tantalum has been used in the construction of a new type of precision calorimeter for studying the dissolution of metals and oxides in strong acids. It has proved to be ideal with respect to corrosion and is decidedly economical.—M. S.

Specific Heats of Petroleum Vapors. W. H. Bahlke & W. B. Kay. Industrial and Engineering Chemistry, Oct. 1929, pages 942-945.
Diagram and description are given of a calorimeter for measuring specific heats of petroleum vapors. The apparatus is brought to temperature by steam heat, energy input is electrical, and temperatures are measured with thermocouples.—M.E.H.

Automatic Electrical Boiler Regulation (Automatische Kesselregelung auf elektrischem Wege). M. Moeller. Siemens Zeitschrift. July, 1929, pages 408-415.
The paper opens with economical considerations regarding the automatic regulation of boiler operation and outlines their technical problems. Gives next a general description of the new electrical regulation method and finally deals with the different parts subdivided (a) in main regulator (a specially designed piston-manometer), (b) bridge-relays, (c) instruments for returning of signals, (chiefly consisting of a centrifugal tachometer and a differential draft-meter) (d) operation of the waste gas valve, (e) CO_2 waste-gas regulator, (f) draft regulator for the combustion room.—E. F.

PRESSURE

Glass Pressure Gages Without Mercury (Quecksilberfreie Druckmesser aus Glas). H. Ebert. Chemische Apparatur, June 2, 1929, pages 105-106.
An illustrated review of mercury-free pressure gages wholly made of glass containing springs or diaphragms.—E. F.

Automatic Draft Regulation for Brick Kilns (Automatische Zugregulierung fuer Ziegelofen). Tonindustrie Zeitung, Jan. 3, 1929, pages 10-11.
An automatic draft regulator of the Krupp Works which can be employed for any flue is described and illustrated.—E. F.

A Pressure Gauge for Continuous Reading in Moderate Vacua. M. C. Johnson & G. O. Harrison. Journal Scientific Instruments, Oct. 1929, pages 305-308.
The construction and use of a continuous reading pressure gauge for low pressure gas experiments is described. Pressure differences between 1/2 mm. and 2x10-4 mm. of mercury are measurable.—M. B. R.

Measurement of Low Pressures. F. Halle. Zeitschrift fuer angewandte Chemie, May 4, 1929, page 448.
The nature of the light emitted in the field of a Tesla transformer is dependent on the pressure of the gas in the field. A manometer constructed on this principle is particularly adapted to the measurement of low pressures in various parts of an enclosed apparatus. Abs. Bull. Kodak Res. Labs.

Osmometer for the Measurement of the Osmotic Pressure of Colloids. A. Gregant & A. Boutroux. Journal de Chimie Physique, April 25, 1929, pages 224-228.
Two hemispherical cells are separated by a semi-permeable membrane. Each hemisphere carries capillary tubes one of which contains a tap. The capillaries run perpendicular to the diaphragm. One cell contains the hydrosol and the other some of the ultra-filtrate from the hydrosol. Diffusion of the ultra-filtrate into the hydrosol is allowed to take place for several hours with the tap closed. On opening the tap, the membrane regains its former position and the liquid which has gone through causes a shift in the meniscus of the capillary. The resulting pressure can be calculated from the increase in volume or measured directly by opening the tap to a suitable pressure gage.—Abs. Bull. Kodak Res. Labs.

SPEED, ACCELERATION, TIME

Methods of Timing High-Speed Races. C. M. Mason. Nature, Aug. 31, 1929, pages 318-311.
The errors in timing races with stop watches and recording chronographs for motor-car races, and the method of timing airplane races are discussed. A method of timing airplanes consisted in using a camera fitted with open sights, capable of rotation about a vertical axis. A camera was used at each station of the course. The open sights were directed on the airplane by each observer, and an arrangement was fitted whereby the camera shutter was automatically tripped when the axis of lens was directed to the starting (or finishing) point. Simultaneously with the tripping of the shutter, a recording pin marked the moving tape of a chronograph. In timing high-speed races, where the airplane starts and finishes at the same point a motion picture camera is used to record the passage of the machine and the reading of two Veeder counters. These counters are electrically driven, and controlled by a tuning fork giving ten complete vibrations a second. A variant of this method consists in using a motion picture camera at each end of a straight course, pointed normally to the course. The film moves at constant speed in each camera across a narrow slot, giving a continuous photograph of a narrow strip defining the starting or finishing of the plane. The two films are synchronized and marked with regular time intervals. The author suggests the following method: A camera is so fixed that its position is accurately known, and a single photograph is taken when the plane is known to be in the field. Behind the plate is put a photo-electric cell which records instantly on a chronograph through suitable amplifiers, or photographically using a string galvanometer, the exact moment of exposure of the plate. From the plate itself the exact distance of the airplane from the true starting or finishing point can be calculated.—Abs. Bull. Kodak Res. Labs.

Pilots' Log Kept Automatically by Recording Clock. Aero Digest, Jan. 1930, page 124.
The Ust-clock is a time mechanism which records on a chart the working time and idling time of an airplane.—M. L. M.

Crystal Clock. Science, Aug. 30, 1929, page 12.
A description of experiments by Dr. W. A. Marrison of the Bell Telephone Laboratories and a device for using electrical vibrations of a section of a quartz crystal as a time regulator instead of a pendulum.—Abs. Bull. Kodak Res. Labs.

New Photographic Instrument. Camera, Oct. 1929, page 227.
Describes the photographic accelerameter, a device for accurate recording of an automobile's acceleration ability; a fifth wheel operating from the running board actuates two disks, one marked in feet and the other in tenths of a foot. A motion picture apparatus connected electrically to a clock takes a picture each second of the disks as they record the number of feet traveled in each second.—Abs. Bull. Kodak Res. Lab.

Time Lapse Camera Controller. Filmtechnik, Apr. 20, 1929, page 202-203; Lichtbildbuehne, Apr. 27, 1929, page 18.
A self-contained time lapse apparatus of Askania manufacture is described. The device consists of two essential parts: (1) Time relay, and (2) motor drive for the camera. Time periods are: 15, 20, 30 and 40 sec.; 1, 2, 5, 10, 15, 20, 30 and 40 min.; 1, 2, 5, and 10 hr. The automatic relay switches on the lights operate the camera for the desired number of pictures, and switches off the lights.—Abs. Bull. Kodak Res. Labs.

A Precision Method of Calibrating a Tuning Fork by Comparison with a Pendulum. Charles Moon. Bureau of Standards Journal of Research, Feb. 1930, pages 213-219.
A photographic method for determining the relative frequency of a tuning fork and pendulum is described in which no energy is drawn either from the fork, the pendulum, or from the fork-driving circuits. A photographic record is obtained from which the frequency of the fork, the amplitude of the fork and the amplitude of the pendulum are obtained. The accuracy of the timing is such that the time interval for an integral number of fork vibrations can be determined to 20 microseconds. If the pendulum is timed over an interval of one second, the error in frequency will be —0.002 per cent. If the time interval is increased to n seconds, the error will be $\pm 1/n$ 0.002 per cent. Irregularities in relative frequency have been found which are thought to be due to a variable rate of the pendulum caused by microseismic movements of the building. Curves are given showing the frequency amplitude relation for two forks (one of steel and one of elinvar) when vibrating freely.

PHYSICAL TESTING

Relation Between Strength and Temperature of Refractory Material. (Beziehung zwischen Festigkeit und Temperatur bei feuerfesten Baustoffen). Dr. H. Hirsch. Tonindustrie Zeitung, Jan. 3, 1929, pages 2-8.
A testing method for the determination of resistance to compression of refractory material at elevated temperatures is given. Chamotte bricks yield between 1080° and 1200° C. A maximum exceeding compressibility at ordinary temperatures has been found. Above 1200° softening takes place. The influence of the gas phase and flux es are discussed. Behavior of silica, magnesite and alumina bricks are investigated. Includes bibliography.—E. F.

Tests of Materials Used in Piping of Steam at High Temperature (Essais des materiaux employes dans les canalisations de vapeur a temperature elevee). Revue Generale de l'Electricite, Oct. 12, 1929, pages 557-580.
Two communications by Guillet, Galibourg, and Samsoen reprinted from "Comptes Rendus des Seances de l'Academie des Sciences," May 6, and May 29, 1929. The first describes the modification of the Martens mirror extensometer used, and the means adopted for maintaining the temperature of the test piece constant at 450°C., and gives some results obtained with a series of carbon steels. The second presents results obtained with nickel and nickel-chrome steels.—M. S.

Hardness Testing. A. F. Shore. Electrician, Nov. 29, 1929, page 672.
A Monotron hardness indicator has been developed in which pressure required to produce a standard impression is measured. A spherical diamond indenter is used and the instrument is particularly adaptable to measurements of surfaces hardened by the nitriding process and tengsten carbide alloys.—W. H. B.

Test Method for Cast Iron. (Les Methodes d'Essai de la Fonte). A. le Thomas & R. Bois. Revue de Fonderie Moderne, Sept. 25, 1929, pages 444-461.
Summarizing report and critical opinion of all applied methods and machines for testing the properties and qualities of cast iron.—G. N.

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Brown Instrument Co.
Esterline-Angus Company
Foxboro Co.
Leeds & Northrup Co.

Fatigue in Steels for Shafts. (Ermuedungseigenschaften von Kurbelwellenstahl). Dr.-Ing. Matthaes. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The report is a survey of investigations carried on by the "Deutsche Versuchsanstalt fur Luftfahrt." Chemical composition, structure, grain size, content of non-metallic inclusions, physical properties of generally applied steels for this purpose are given, as well as results on fatigue tests with shafts of 80-140 kg/mm$_2$ tensile strength. Different shaped shafts were examined.—G. N.

Tensile Strength of Pipe Connections. (Die Festigkeit und Beschaffenheit bisheriger und neuerer Muffenverbindungen und Anleitung zur sachgemassen Verschwiessung). F. Weckwerth. Archiv fuer Eisenhuettenwesen, Sept. 1929, pages 185-198; Stahl und Eisen, Oct. 10, 1929, pages 1491-1493.

Description and investigation of welded tube connections, according to old and new methods of manufacturing. Training of welders is emphasized.—G. N.

Formation of Fatigue Cracks and the Relation between Alternating Bending Strength and Static Tensile Properties. (Ueber die Ausbildung von Ermuedungsrissen und die beziehung der Dauerbiegefestigkeit zu den statischen Festigkeitswerten). W. Herold. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The influence of notch effects, of small surface defects or of internal defects, as for instance inclusions of slags of poorly welded blow holes, or also that of a coarse grain decrease of the fatigue limit are dealt with. As regards the relationship between alternating bending strength and tensile properties, it is pointed out that alternating bending strength generally increases with the tensile strength but endurance strength increases slower than compression strength. Alloy steels have a higher fatigue limit than plain carbon steels.

Machine and Apparatus for Fatigue Tests. (Maschinen und Vorrichtungen fuer Dauerpruefungen. W. Deutsch. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The paper gives a general outline of machines, as applied to fatigue testing.—G. N.

Endurance Tests. (Dauerbiegeversuche). P. Ludwik. Paper Deutscher and Oesterreichischer Verband fuer die Materialpruefung, Vienna, Oct. 8-11, 1929.

The author discusses the theoretical basis of endurance tests, considers the relations between fatigue strength and other physical properties and reports on a large number of tests which were carried on recently by the technische Versuchsanstalt of the Technische Hochschule in Vienna as alternating bending tests with reinforced concrete bars, tests with a large variety of steels, cast iron, light metals, copper, zinc, brass in different machines (C. Schenk, A. I. Amsler tip machine). See Metals & Alloys, Vol. 1, Aug. 1929, page 75.—G. N.

Fatigue Strength and Construction. (Dauerfestigkeit und Konstruktion). O. Foeppl & G. von Heydekampff. Paper Deutscher und Oesterreichischer Verband fuer die Materialpruefung, Vienna, Oct. 8-11, 1929.

In reference to the investigations of the Wohler Institute Braunschweig, the viewpoint of the fitness of construction materials are considered. The importance of a high polish after grinding to improve the fatigue qualities is emphasized. Fatigue limit can be raised 10-20% by pressing the surface of materials in rolls.—G. N.

A New Test Method for Sheets. (Ein neuses Pruefuerfahren fur Feinbleche). E. Siebel & A. Pomp. Mitteilungen Kaiser Wilhelm Institut fuer Eisenforschung, 1929, Vol. II, No. 18, (Report 136) pages 287-291; Stahl und Eisen, Dec. 26, 1929, pages 1866-1868.

The new method was developed as the conditions of power and deformation in the usually applied Erichsen method are not definite. The new method eliminates this disadvantage. The appratus is described, the theoretical principles of the method are outlined and the results of tests with various materials are given.—G. N.

Hardness Tests of Chilled Castings. (Die pruefung der Haerte von Schalenhartguss). O. Kenne. Krupp'sche Monatshefte, Dec. 1929, pages 209-203.

Numerous measurements various Scleroscope hardness testers give various readings with the same test piece. Also one and the same instrument gives divergent readings, which decrease with very hard material. A method is proposed for checking scleroscopes.—G. N.

A New Special Testing Machine for Cast Iron. (Ein Neues Sonderpruefverfahren fur Gusseisen). Giesserei-Zeitung, Nov. 1, 1929, pages 620-621.

Description of a new testing machine for cast iron, built by Mohr & Federhoff, Mannheim, Germany, which is especially used for making shearing tests, according to a proposal by Rudeloff and Sipp.—G. N.

A New Stress Limit and its Relation to Fatigue Strength. (Eine neue Spannungsgrenze und ihre Beziehung zur Dauerfestigkeit). Dr.-Ing. Sachs. Paper Deutscher and Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The Bauschinger effect depends upon the preceding deformation of a material and increases with the deformation to a certain limit. Stresses which cause slight deformation have no influence on the Bauschinger effect of a certain group of non-ferrous metals. The Bauschinger effect originates at stresses above elastic limit and yield point. However iron and steel show the Bauschinger effect, as soon as permanent deformations can be observed with fine extensometers. It is confirmed that permanent deformations in steel can occur below the yield point. Elastic limit and yield point are less important for the phenomenon of fatigue.

Fatigue Cracks and Fatigue Strength. (Dauerbruche und Dauerfestigkeit Erfahrungen und Versuchsergebnisse aus dem Reichsbahnbetrieb). Dr.-Ing. Kuhnel. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The author deals with fatigue in 3 groups, fatigue cracks due to interior defects, to surface defects and those which can not be traced back to a certain failure in the material. Tests in 3 different types of machines (Schenk, Amsler, Krupp) were carried on with low and medium carbon steel, structural steel, spring steel and cast iron. The results were reported.—G. N.

A New Dead-Weight Testing Machine of 100,000 Pounds Capacity. Bureau of Standards Journal of Research, Feb. 1930, pages 261-264.

The functions of the Bureau of Standards are outlined, and the importance of calibrating testing machines is emphasized. The different methods of calibrating testing machines (A. S. T. M. specifications) are given, and the limitations of each are discussed. The development of the proving ring is mentioned, and the need for apparatus for applying, preferably by dead weights, forces which are known accurately is brought out. The dead-weight machine, capacity 100,000 pounds, which has been installed at the bureau is described and illustrated. Particular attention is given to the accuracy of the forces which can be applied by this machine and the precautions for maintaining the accuracy.

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Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Co.
Thermometer
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Wilson-Maeulen Company, Inc.
Thermostat
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Taylor Instrument Companies
Westinghouse Elec. & Mfg. Co.
Thickness
Esterline-Angus Company
H. Z. Schniewind
Time
Brown Instrument Co.
Esterline-Angus Company
Foxboro Co.
Stromberg Electric Co.
Tagliabue Mfg. Co., C. J
Vacuum
Brown Instrument Co.
Esterline-Angus Company
Foxboro Co.
Meriam Co.
Unit Heater Valve—Motor Operated
American Radiator Company
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Taylor Instrument Companies
Water Level
Bristol Company
Brown Instrument Co.
Esterline-Angus Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

COORINATOGRAPHS
COUNTERS—Revolution
Bristol Company
Brown Instrument Co.
H. Z. Schniewind
Stroke
Bristol Company
Esterline-Angus Company

COUPLING TRANSFORMERS
General Radio Company

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Esterline-Angus Company
Leeds & Northrup Co.

CURRENT REGULATORS
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DEFORMETER (Beggs)
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Gas
American Meter Co.
Electric
Westinghouse Elec. & Mfg. Co.

DENSITOMETERS
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DENSOMETERS
H. Z. Schniewind

DIVIDING HEAD
Optical
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.

DIVIDING MACHINES
Gaertner Scientific Corp.

DRAFT GAGES—see Gages

DYNAMIC BALANCING EQUIPMENT
Electrocon Corporation

EARTH CURRENT METERS
Rawson Elec. Inst. Co.

ELECTRIC TELEMETER
Southwark Fdry. & Mach. Co.

ELECTRIC WAVE FILTER SECTIONS
General Radio Company

EMPLOYEES' "IN AND OUT" TIME RECORDERS
Stromberg Electric Co.

ENGINE INDICATORS
Commercial Engg. Labs.

EXTENSOMETER
H. Z. Schniewind
Southwark Fdry. Mach. Co.

FATIGUE TESTERS
H. Z. Schniewind

FAULT FINDERS
General Radio Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

FLASH & BURNING POINT TESTERS
Akatos, Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Co.

FLOW METERS
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.

FLUXMETERS
Leeds & Northrup Co.
Rawson Electrical Instr. Co.

FOLDING TESTER
H. Z. Schniewind

FREQUENCY METERS
Indicating
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Inst. Corp.
Controlling
Leeds & Northrup Co.
Recording
Bristol Company
Esterline-Angus Company
Leeds & Northrup Co.
Standards
General Radio Co.

FUEL ANALYSIS APPARATUS
Burgess-Parr Co.

FUEL FLOW INDICATOR
Commercial Engg. Labs.

GALVANOMETERS
Brown Instrument Co.
Charles Engelhard, Inc.
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

GAS ANALYTICAL METERS
Chemical
American Meter Co.
Tagliabue Mfg. Co., C. J.
Electrical
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.

GAS LEAK INDICATORS
Taylor Instrument Companies

GAS-METERS
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.

GASOMETERS
American Meter Co.

GAGE RODS
Tagliabue Mfg. Co., C. J.

GAGES
Absolute Pressure
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Amplifying
B. C. Ames Co.
Federal Products Corp.
Comparator
B. C. Ames Co.
Federal Products Corp.
Cylinder
B. C. Ames Co.
Federal Products Corp.
Depth
B. C. Ames Co.
Federal Products Corp.
Dial
B. C. Ames Co.
Federal Products Corp.
H. Z. Schniewind
Differential Pressure
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Draft
Bristol Company
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Drill
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Grinding
Federal Products Corp.
Liquid Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Loss of Head
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Pitch Diameter
Federal Products Corp.
Pocket
H. Z. Schniewind
Pressure
American Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure-Temperature
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.
Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Profile
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Rain
Taylor Instrument Companies

A Method of Measuring the Stress-Strain Relations of Wet Textiles with Application to Wet Rayons. Homer A. Hamm and R. E. Stevens. Bureau of Standards Journal of Research, Dec. 1929, pages, 927-936.

An immersion tank has been developed as auxiliary equipment for a recording stress-strain tester. This tank is built around the lower jaw of the testing machine. It is equipped with suitable stirrer, heater, and heat-control apparatus. The textile, in this method, is fastened in the jaws of the testing machine, liquid is poured in the tank, and after a suitable immersion period the break is made. The results of a series of tests on rayons broken dry, broken dry after wetting in water at 20°C, and at 100°C., and broken wet at various temperatures are given.

Physical Testing of Rubber Samples. Rubber Age, Jan. 25, 1930, pages 429-430.

Report on the work of the Physical Testing Committee, Rubber Division, American Chemical Society.

VIBRATION, SOUND, LIGHT, COLOR

Fastness Tests Committee Interim Report on Standardization of Methods of Testing the Fastness of Dyed and Printed Materials. Journal Society of Dyers & Colourists, July 1929, pages 214-219.

Of the large number of different fastnesses of general and technical importance, the Fastness Tests Committee of the Society of Dyers and Colourists has decided to investigate first the following three: "Fastness to Light," "Fastness to Perspiration," and "Fastness to Washing."—Abs. Bull. Kodak Res. Labs.

Apparatus Utilizing Photo-Electric Cells for Measuring Colour Temperature and Lumens of Incandescent Electric Lamps. G. T. Winch. Journal Scientific Instruments, Dec. 1929, pages 374-379.

Describes the development and construction of a photo-electric apparatus for measuring the color temperature and luminous output of incandescent electric lamps. Both temperature and lumen scales are linear, thus facilitating the calibration of apparatus.

New Exposure Meter. R. J. Garnotel. Photo pour tous, July 1929, pages 134-136.

The Filmograph is a pocket photometer by means of which the brightness of the scene is compared with that of a filament. Constant voltage is obtained by adjusting a calibrated rheostat, and the brightness of the lamp is reduced by a sliding wedge, from which the required exposure is read.—Abs. Bull. Kodak Res. Labs.

Photo-Electric Photometer of the Dominion Observatory. F. Henroteau. Popular Astronomy, May 1929, page 267.

A brief description of the photo-electric photometer recently installed at the Dominion Observatory.—Abs. Bull. Kodak Res. Labs.

Mechanical Method of Measuring Sound Pressure. B. E. Eisenhour & F. G. Tyzzer. Journal Franklin Institute, Sept. 1929, pages 397-404.

A purely mechanical instrument for measuring sound pressure is described.—Abs. Bull. Kodak Res. Labs.

Absolute Measurement of Sound Intensity. F. D. Smith. Proceedings Physical Society, London, Aug. 15, 1929, pages 487-495.

Sound is received by a moving coil receiver and the signal amplified. This is compared with the effect of a small, known, electromotive force applied to the receiver. It is possible to use a high degree of amplification and thus to measure feeble sounds.—Abs. Bull. Kodak Res. Labs.

Spectrograms of Colored Arcs. Filmtechnik, Mar. 2, 1929, pages 88-90.

Spectrograms are shown of the arcs produced with white and yellow Columbia and Siemen's carbons and with the combination of white and yellow carbons of each brand.—Abs. Bull. Kodak Res. Labs.

Determining the Translucence of Paper. W. Holwech. Paper Trade Journal, Sept. 5, 1929, page 55.

A Konig-Martens polarization photometer was used. Monochromatic light of different definite wave-lengths was used, so that some of the wave-lengths will fall within absorption limits of the paper listed.—Abs. Bull. Kodak Res. Labs.

The Measurement of Gloss. A. H. Pfund. Journal Optical Society, Jan. 1930, pages 23-26.

The brightness of the image of a source reflected specularly from the samples mounted on a circular cylinder, which is spun rapidly, is photometered by means of an optical pyrometer. Results show that gloss so measured is independent of the brightness of the back-ground.

The Absorption of Sound at Oblique Angles of Incidence. P. R. Heyl, V. L. Chrisler, & W. F. Snyder. Bureau of Standards Journal of Research, Feb. 1930, pages 289-296.

As a consequence of the experiments described in this paper the conclusion has been reached that the tube method of measuring absorption is limited in its application to relative comparison of samples of similar nature, and that for absolute values of absorption the reverberation method is the only trustworthy one.

A New Flicker Radiometer. Donald C. Stockbarger and Laurence Burns. Review of Scientific Instruments, February 1930, pages 76-83.

When radiation is allowed to pass alternately through 1 and the other of 2 filters having identical transmissions for all wave lengths except those lying in a narrow spectral region, a flicker is produced which is a function of the intensity of the radiation within that region. A radiometer making use of this principle is described in detail. The filters are cut in the shape of sectors and are so arranged as to form a solid wheel. The filtered radiation passes through a window into a magnesium photoelectric cell fabricated of Vitaglass. Oscillograms show that the a.c. component of the photoelectric current, after electrical filtering and amplification, is sinusoidal.

Infra-Red Transmission of the Flesh. C. Hawley Cartwright. Journal Optical Society, February 1930, pages 81-84.

The spectral energy of a light transmitted through the cheek was tested photographically in the region of $\lambda 0.86\mu$, and also by a spectrometer throughout the whole spectrum. A very sensitive vacuum the remocouple was used. The photographs of the spectrum showed 14% transmission of $\lambda 0.86\mu$ through the cheek. The cheek transmitted a maximum of 20% at $\lambda 1.15\mu$ and the water in the body cut off the longer wave lengths. The spectral energy transmitted by bacon fat was found to be similar to that of the cheek; however, it transmitted nearly 5 times as much energy. The ordinary incandescent electric light with filters to cut out the visible and infrared beyond $\lambda 1.4\mu$ is ideal for deep penetration of light into the body.

Recording
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Esterline-Angus Company
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Strain
Southwark Fdry. & Mach. Co.
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Wind
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Westinghouse Elec. & Mfg. Co.
Testing Devices
Westinghouse Elec. & Mfg. Co.

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Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Rubicon Company
Controlling, Recording
Leeds & Northrup Co.

HYDROMETERS
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Taylor Instrument Companies

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
H. Z. Schniewind
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

IMPACT HARDNESS TESTER
H. Z. Schniewind

IMPACT TESTING MACHINES
Akatos, Inc.
H. Z. Schniewind
Alternating

INDICATORS—See Gauges

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Rubicon Company

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Jewell Electrical Instrument Co.
Rubicon Company

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Westinghouse Elec. & Mfg. Co.
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Leeds & Northrup Co.
Rubicon Company
Westinghouse Elec. & Mfg. Co.

INTEGRAPHS & INTEGRATORS
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JOB TIMING RECORDERS
Stromberg Electric Co.

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Foxboro Co.

KILOVOLT AMPRERE METERS
Esterline-Angus Company

KLYDONOGRAPHS
Westinghouse Elec. & Mfg. Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.

LENGTH MEASURING MACHINES
Gaertner Scientific Corp.
H. Z. Schniewind

LEVELS
Centering
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Engineer's, Wye, Precision
Prism
Taylor Instrument Companies

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American Instrument Company

LOCOMOTIVE INDICATORS

LUSTER METERS
Akatos, Inc.

MAGNETOMETERS
Rubicon Company

MANOMETERS
American Paulin System, Inc.
Brown Instrument Co.
Foxboro Co.
Meriam Co.

MASTER CLOCKS
Gaertner Scientfiic Corp.
Stromberg Electric Co.

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Instrument Publishing Co.

MEGOHMMETERS
Leeds & Northrup Co.
Rubicon Company
Herman H. Sticht and Company

MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

MELTING POINT APPARATUS
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas
American Meter Co.

METER TESTERS, Gas
American Meter Co.

MICROMETERS
Gaertner Scientific Corp.
H. Z. Schniewind

MICROAMMETERS
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.

MICROFARADMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

MICRO PYROMETERS
Akatos, Inc.

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Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Industrial App. & Inst. Co.
H. Z. Schniewind
Spencer Lens Co.
Metallographic
Akatos, Inc.
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Spencer Lens Co.
Petrographical
Akatos, Inc.
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Spencer Lens Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Industrial App. & Inst. Co.
Spencer Lens Co.

MICROTOMES
Bausch & Lomb Optical Co.
Spencer Lens Co.

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General Radio Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.

MILLIVOLTMETERS
Bristol Company
Charles Engelhard, Inc.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Taylor Instrument Companies
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.

MOTION RECORDERS
Mechanical
Bristol Company

MULTIMETERS
Rawson Electrical Instrument Co.

MULTIPLIERS
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Weston Electrical Inst. Corp.

NEON FILLED TUBES
Argeo Laboratories, Inc.

NEPHELOMETERS
Akatos, Inc.

OHM METERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Herman H. Sticht and Company
Weston Electrical Inst. Corp.

OIL TESTING APPARATUS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

OIL TESTING EQUIPMENT

Method for the Measurement of the Effective Transparency of Photographic Objectives. J. Hrdlicka. Comptes Rendus, July 22, 1929, pages 153-155.

The author advocates photographic photometry for determining the effective transparency of a photographic objective and quotes an instance in which this value does not check with the maker's f/ value within a reasonable amount.—Abs. Bull. Kodak Res. Labs.

International Commission of Illumination. Plenary Session at Saranac-Inn (September 1928). XI. Work of the Committee on Diffusing Materials (Commission internationale de l'Eclairage. Session pleniere de Saranac-Inn (September 1928). XI. Travaux du Comite des Materiaux diffusants. Revue Generale de l'Electricite, Nov. 16, 1929, pages 771-781.

Includes condensed translations of the optical properties of diffusing glasses and their definition, by M. Piram; the methods of measuring these properties, by L. Block; precise measurements of optical transmission reflection, and absorption factors, by J. M. Waldram; experimental studies of liquid suspensions of particles, by E. Lax, M. Pirani, and H. Schoenborn; and factors of diffuse and direct transmission and their measurement, by W. Dziobek.—M. S.

A Monochromator.—The Photochemical Decomposition of Benzo-quinone in Water and in Alcohol. P. A. Leighton & G. S. Forbes. Journal American Chemical Society, Dec. 1929, pages 3549-3559.

In this article appears the description of a monochromator, which includes a fused quartz prism and two fused quartz lenses. The light source is a mercury vapor arc in quartz, the electrodes being watercooled.—M. E. H.

Forms of Gas-Filled Photoelectric Cells: Their Properties and Calibration. J. Kunz & V. Shelford. Review of Scientific Instruments, Feb. 1930, pages 106-117.

The paper is concerned with the measurement of the duration, intensity, and quality of sunlight, and with the measurement and control of artificial light in experiments designed to reproduce some of the conditions found in nature.

CHEMICAL ANALYSIS

Glass Electrode Apparatus for Measuring the pH Values of Very Small Volumes of Solution. D. A. Mac Innes & M. Dole. Journal of General Physiology, July 20, 1929, page 805-811.

With the electrode, pH measurements can be made on volumes as small as two drops. E.m.f. measurements are made by means of an electrometer and potentiometer.—Abs. Bull. Kodak Res. Labs.

Apparatus for Visual Conductivity Titration and Conductance Measurement. O. Pfundt. Chemische Fabrik, Apr. 17, 1929, pages 184-186.

The usual telephone type of detector for the wheatstone bridge is replaced by a visual indicator consisting of a vacuum thermocouple and a mirror galvanometer. Greater rapidity of measurement is claimed.—Abs. Bull. Kodak Res. Labs.

A Method of Determining Hydrogen Ion Concentration by Means of the Antimony Electrode. J. J. Shukoff & G. P. Awseiewitsch. Zeitschrift fuer Elektrochemie, June 1929, pages 349-352.

An antimony electrode has been prepared by depositing the metal from a 25% solution of antimony trichloride in acetone upon the amalgamated surface of a platinum wire by means of electrolysis. Freedom from drifting potential and good reproducibility are claimed for the electrode. A linear relationship was found to exist between the observed e.m.f. and pH when employing the normal calomel electrode.—Abs. Bull. Kodak Res. Labs.

An Objective Physical Method for the Determination of Sugars in Solution. J. W. Meijer. Review of Scientific Instruments, Feb. 1929, pages 69-75.

The method described enables measuring rotating substances dissolved in a pure colorless liquid. It can be used to measure glucose concentrations 5 times smaller than the lowest concentration which can be measured with the Lippich type polarimeter and 10 times smaller than the lowest concentration measurable with Laurent's polarimeter.

The Effect of Light on Silver Chloride in Chemical Analysis. G. E. F. Lundell and J. I. Hoffman. Bureau of Standards Journal of Research, Jan. 1930, pages 109-114.

The experiments described in this paper show the direction and magnitude of the errors that may be expected in analytical work if silver chloride is not protected from light. Exposure to light during precipitation always causes positive errors if silver is in excess, and negative errors if hydrochloric acid is in excess. Exposure of dry precipitates has very little effect. The error, if any, is negative and becomes greater if the dried precipitate is moistened before exposure or if the precipitate is exposed before drying. Exposure to light probably produces a mixture of metallic silver and silver chloride.

A Gravimetric Method for the Determination of Ruthenium. Raleigh Gilchrist. Bureau of Standrad Journal Research, Dec. 1929, pages 993-1004.

A gravimetric procedure for the accurate determination of ruthenium by hydrolytic precipitation from chloride solution has been developed. A delicate test for the qualitative detection of small quantities of ruthenium, using thiourea as a reagent, is described.

pH Measurement with the Glass Electrode and Vacuum Tube Potentiometer. L. W. Elder, Jr. Journal American Chemical Society, Nov. 1929, pages 3266-3272.

The vacuum tube potentiometer as described by Elder and Wright, Proc. Nat. Acad. Sci., 14, 936 (1928), has been modified in order to increase the sensitivity and simplicity of the apparatus. Comparative measurements with this instrument and the Lindemann quadrant electrometer have been made and various glass stocks tested.—M. E. H.

Application of the Spectrographic Analysis. (Die Anwendung der spektrographischen Analyse im Eisenhuttenlaboratorium). K. Kellermann. Archiv fuer Eisenhuettenwesen, Sept. 1929, pages 205-211; Stahl und Eisen, Oct. 17, 1929, pages 1520-1521.

Kellermann describes a new spectrographic method with high sensibility which permits the rapid analysis of materials without errors, provided that the element tested is present to an amount not over 1%. The method is especially suitable for laboratories of alloy steel plants.—G. N.

The Application of Microchemistry to Testing Materials. (Die Mikrochemie im Dienste der Materialpruefung). F. Feigl. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

A survey of the historic development of microchemistry is given; the advantages which this relatively young chemical science offers for testing materials are discussed. Microchemistry opens new viewpoints and will gain in importance. Results of research of the pioneers in this field, F. Emich & F. Progl, are presented.—G. N.

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Radioactive and Spectrosopic Methods of Microchemistry. (Ueber Radioaktive und spektroskpische Methoden in der Mikrochemie). F. Paneth. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The scope of application of radioactive and spectroscopic methods in analyzing microquantities of materials is outlined. According to investigations of Gerlach it is possible to find by spectroscopic methods the location of micro impurities in metals. Examples of the sensibility of spectroscopic methods in analyzing gases, quantitative as well as qualitative, are given.—G. N.

Quantitative Inorganic Analysis. (Quantitative anorganische Mikroanalyse). R. Strebinger. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The possibilities and importance of the microanalysis when applied to inorganic materials are considered and emphasized.—G. N.

The Magnetic Determination of Carbon in Steel with the Malmberg Carbometer. (Die magnetische Schnellbestimmung des Kohlenstoffs im Stahl mit dem Karbometer von Malmberg). Paul Klinger & Herbert Fucke. Archiv fuer Eisenhuettenwesen. Nov. 1929, pages 347-352.

The authors test the magnetic determination of carbon with the Malmberg Carbometer. Based on test melts calibration curves for pure carbon steels and the influence of the individual alloying constituents on this is determined by corrections. The instrument was found very satisfactory in the melting operation, especially if the same steels are manufactured all the time.

What We Do Know About Chromium Plating. Pt. 2. Methods of Analysis of Chromium Plating Bath for Determining Sulfate, Chromic Acid, Trivalent Chromium, Iron and Copper. Charles H. Proctor. Metal Cleaning & Finishing, Aug. 1929, pages 349-352.

Gives details of a precedure which has been found satisfactory, both from the stand-point of operations and results.—M. S.

X-RAY TESTING AND EQUIPMENT

X-Ray Diffraction by Plane Gratings. J. A. Prins. Nature, Sept. 7, 1929, page 370.

Differences in wave-length as determined by grating and crystal diffraction are accounted for by hitherto unnoticed properties of gratings.—Abs. Bull. Kodak Res. Labs.

Studies on Metal Structure by Means of X-Rays. (Aufbau der Metalle im Roentgenbild). F. Wever. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

X-rays are the only possibility to reveal the atomic structure of metals and to build up an atomic metal science. Investigations of Westgren and Phragmen show that the generation of certain structures of copper-silver alloys is bound to the observation of a determined quantitative relation between atoms and electrons. The possibilities for the development of new iron alloys by means of the structure analysis are outlined.—G. N.

Deformation of Metallic Materials as Revealed by X-Rays. (Verformung Metallischer Werkstoffe im Roentgenbild). Dr.-Ing. Sachs. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The far-reaching possibilities in applying X-Rays to studies of the deformation of metals are considered. Investigations on cold drawn wire, rolled sheets, effects of re-crystallization, interior stresses in metals are referred to.—G. N.

Quantitative X-Ray Analysis. (Quantitative Roentgenanalyse). H. Stintzing. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The advantages of the X-Ray emission method for quantitative chemical analysis are considered. Simplicity of spectrum and accuracy are the main features. The method was improved by Stintzing and sources of errors were eliminated.—G. N.

Investigations of Materials by Means of X-Rays. (Untersuchung der Werkstoffe mit Roentgenstrahlen). R. Glocker. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The general characteristics of X-Rays, the methods and principles of Application, X-Ray tubes and some examples of practical X-Ray investigations are outlined.—G. N.

X-Ray Investigations of Fractures. (Roentgenuntersuchungen an Bruchen). F. Regler. Paper Deutscher und Oesterreichischer Verband fuer Materialpruefung, Vienna, Oct. 8-11, 1929.

The importance of X-Ray examination in testing materials is emphasized.—G. N.

Portable Electroscope Incorporating Some Unusual Features. F. W. Bishop. American Journal of Roentgenology, May 1929, pages 491-494.

The brass, lead-lined cases contain a parallel plate ionization chamber, an electroscope leaf system, and a spark coil charging device. Removable side tubes carry lamp and scale. An external flexible cable with thimble type ionization chamber is readily attachable. The instrument is rugged, portable, and can be used in a variety of ways for measurement of X-ray and gamma ray intensity. —Abs. Bull. Kodak Res. Labs.

Neon "Glow" Lamp as a Polarity Indicator. F. W. Bishop. American Journal of Roentgenology, June 1929, pages 599-600.

The lamp is inserted in place of the usual polarized ammeter used as a polarity indicator on X-ray machines, and the polarity is indicated by the side of the lamp which glows.—Abs. Bull. Kodak Res. Labs.

Progress in the Physics of X-Rays and Their Application. M. Ponte. Revue Generale des Sciences, Jan. 15, 1929, pages 11-21.

The first of a series of articles on the subject to appear in this publication. It deals primarily with the production of X-Rays. The X-ray tube is described in detail and the author deals with the X-ray spectrometer and methods of studying X-ray spectra.—Abs. Bull. Kodak Res. Lab.

Studies in X-Ray Intensity Measurement H. W. V. Mayneard. British Journal of Radiology, June 1929, pages 267-297.

By means of a small ionization chamber connected to a gold leaf electrode, measurements were made of the distribution of X-ray intensity in a water phantom with the X-ray tube operated as for therapeutic purposes. Tube voltage was measured both spectrographically and by sphere gap, and effective wave-length determined by absorption measurement.—Abs. Bull. Kodak Res. Labs.

Roentgen Ray Apparatus. K. Mayer. British Journal of Radiology, Sept. 1929, page 443.

A Bucky diaphragm in the form of an endless belt which travels around the cassette; when the elements are between the cassette and the patient, they are in correct alignment with the tube so as to be effective in removing scattered radiation.—Abs. Bull. Kodak Res. Labs.

Recommendations of the Industrial X-Ray Unit Committee. Radiology, Oct. 1929, page 370.

The report gives the recommendations adopted by the Second International Congress at Stockholm regarding the unit X-ray intensity and the specifications of X-ray quality.—Abs. Bull. Kodak Res. Labs.

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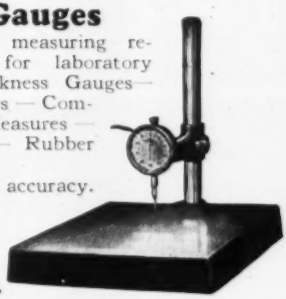

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THE ENGINEER'S HANDBOOK OF INDUSTRIAL INSTRUMENTS.

M. F. BEHAR, INSTRUMENTS, Vol. 3, No. 4, April 1930, pages 219-244, 27 figs.

Chapter II, Part 3—Thermoelectric pyrometers. This is the fourth installment of a series of articles on industrial instruments. Indicating thermoelectric pyrometers are considered in detail: Essential Parts, Circuits and Methods; Question of Resistance.

MEASUREMENT OF AIR FLOW.

E. OWER, INSTRUMENTS, Vol. 3, No. 4, April 1930, pages 245-250, 2 figs.

Chapter IV (cont'd). This is the third installment of a series. The following is considered: Stream Line Flow in Pipes; The Resistance of a Pipe of Varying Cross-Section.

MEASUREMENTS—INDUSTRIAL & SCIENTIFIC.

DR. WALTER BLOCK, INSTRUMENTS, Vol. 3, No. 4, April 1930, pages 251-259.

Chapter III. Measuring System and General Physical Constants. This installment of this series on measurements considers the fundamentals of the physical measuring system and the absolute system of measurements.

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